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**Agricultural Intensification and
Smallholder Crop-Livestock Integration in Rwanda**

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**Submitted for the Degree of
Doctor of Philosophy in Development Studies**

University of Sussex

November 2017

Declaration

I hereby declare that this thesis has not been and will not be, submitted in whole or in part to another University for the award of any other degree.

Signature: _____

UNIVERSITY OF SUSSEX**SUNG KYU KIM****PHD IN DEVELOPMENT STUDIES****AGRICULTURAL INTENSIFICATION AND SMALLHOLDER
CROP-LIVESTOCK INTEGRATION IN RWANDA****SUMMARY**

This thesis is about agricultural intensification and the role of smallholder farmers in the future of agriculture in Rwanda. Intensification of agriculture has been the central objective of policy in Rwanda since independence in 1962. Over five decades, one of the dominant approaches to achieving this goal has been through mixed farming, i.e. the integration of crop and livestock production. However, despite continued efforts to transform agricultural and rural livelihood through mixed farming, many farmers have not achieved intensification. Thus, there seems to be a critical disjuncture between the government's vision of modern agriculture based on increasing levels of intensification and commercialisation, and the ability of many smallholders to engage with this intensification and commercialisation agenda. In this thesis, I argue that the disjuncture between the long-standing policy objective and Rwanda's rural realities poses serious repercussions to the rural development and the livelihoods of millions of smallholder farmers. I substantiate the argument by addressing the following question: "how does the integration of crop and livestock production contribute to agricultural intensification for smallholder farmers in Rwanda?" Firstly, I situate the research context within the historical development of agricultural policies promoting the mixed farming agenda. Secondly, I study two villages in Rwamagana district as rural and peri-urban cases. Various patterns of interactions between crop and livestock production systems are identified, characterised and analysed within the broader household livelihood strategies. Thirdly, I incorporate the life history accounts of farmers with diverse background and capabilities to engage in mixed farming to better understand the wide-ranging issue of livestock-based asset accumulation which is crucial for the crop-livestock integration. Finally, I discuss the implications for the government's continued efforts to transform agriculture and rural livelihoods through mixed farming and possible ways to assist many farmers who lack the resources required for intensification through integrated crop-livestock production.

Acknowledgements

Dare to dream.

I am grateful and indebted to all of you who made this research journey possible. The past four years has been a truly unique experience of deep learning and self-reflection. First and foremost, thank you, Jim and Stephen, for your unfailing support and guidance throughout my doctoral training. I have benefited immensely from your knowledge, patience and encouragement. This thesis could not have been the same without your supervision.

Even before I embarked on the PhD journey, many of you believed and encouraged me to dream and to live that dream. I especially thank Santoso sensei, Dr Judy McLean, Dr Kevin Tiessen, Dr Stephan Vachon, and Professor Rick Barichello for your inspiration and mentorship.

Unforgettable moments at IDS. I cherish every walk that I managed to do during my day of work. Especially the walk to Mother Tree was always uplifting and comforting (Long live the Mother Tree!). I also enjoyed the company of the friendly PhD community at IDS. There were many trials and challenges, but we managed to check and help each other (Comrades, the struggle continues!). Maisa, *shukran* for all your kind support and care. Shilpa, you came to tell me the timely message to 'not give up and just do it' in my first year's crisis. Camilla, it was such a delight to meet at Bukavu border in D.R.C. and Rwanda during our fieldwork.

My utmost respect goes to all the research participants, many of whom were smallholder farmers. You've offered me the most precious gift of all: your trust. Through your life stories and experiences, I've gained much insight on rural livelihoods and development. Your lessons will continue to guide me beyond this research.

Every end is also a beginning. I am looking forward to applying what I have learned during my PhD to whatever work that I will embark on next. "Not my will, but thine, be done".

Rêve de PhD.

C'est accompli.

I am forever grateful to my parents who have taught me to dare to dream. I am always in awe when I look back and reflect on where I come from, how I became who I am, and what a blessing this life has been so far. I am that I am thanks to you.

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List of acronyms

AGM	Annual general meeting
AGRA	Alliance for a Green Revolution in Africa
BLDS	British Library for Development Studies
CICA	Agricultural Information and Communication Centre (a French acronym)
CIP	Crop Intensification Programme
DAP	Diammonium phosphate
EICV	Integrated household living conditions survey (a French acronym)
FAO	Food and Agriculture Organization
FYNDP	Five-Year National Development Plan
GoR	Government of Rwanda
IFAD	International Fund for Agricultural Development
IPAR	Institute of Policy Analysis and Research
ISAR	Institut des Sciences Agronomiques du Rwanda
LID	Livestock in Development
MCC	Milk collection centre
MRNDD	Mouvement républicain national pour la démocratie et le développement
MDR-PARMEHUTU	Mouvement Démocratique Rwandais – Parti du Mouvement pour l’Emancipation de Bahutu
MINADEF	Ministry of Defence
MINAGRI	Ministry of Agriculture and Animal Resources
MINECOFIN	Ministry of Finance and Economic Planning
MINIJUST	Ministry of Justice
MINIPLAN	Ministère du Plan
MINITRAV	Ministère du Travail
NGO	Nongovernmental organisation
NISR	National Institute of Statistics of Rwanda
NPK	Nitrogen-Phosphorous-Potassium fertiliser
OECD	Organisation for Economic Co-operation and Development
OED	Oxford English dictionary
ONAPO	Office National de la Population
OPROVIA	Office National pour le Développement et la Commercialisation des Produits Vivriers et des Productions Animales
PCA	Principal component analysis
PDF	Portable document format
PPP	Private-public partnership
RAB	Rwanda Agriculture Board
RPF	Rwandan Patriotic Front
RWF	Rwandan Franc
TLU	Tropical livestock unit
UN	United Nations
USD	US dollar
USDA	United States Department of Agriculture
WB	World Bank
WHO	World Health Organization

Glossary

Cropping system: The cropping patterns used on a farm and their interactions with farm resources, other farm enterprises, and available technology that determine their makeup.

Fallow: Not cultivating the land for several years, allowing the soil to rest and replenish.

Intercropping: Growing two or more crops simultaneously on the same field per year. Crop intensification is in both time and space dimensions. There is intercrop competition during all or part of crop growth. Farmers manage more than one crop at a time in the same field.

Livestock-in-kind (in-trust): A development practice that helps the rural poor to obtain livestock to increase the financial security of their households.

Livestock ladder: The idea that poor people can gradually build up the herd of small ruminants and through progressive accumulation, work their way up to more valuable livestock such as cattle.

Malthusian trap: The Malthusian trap, in theory, occurs when the population grows faster than the rate of technological advancement and growth in food production. When such imbalance in a society happens, then the standard of living will decline to a point where the food supply is no longer adequate for feeding the population, and the population size will fall to a new equilibrium.

Mixed farming: Cropping systems that involve the raising of crops and animals.

Monocropping: The repetitive growing of the same crop on the same land.

Stover: Originally it referred to the traditional rights of peasants to forage in woodland areas but is now used to describe what is left after harvesting and cropping.

<i>Ananas comosus</i>	Pineapple
<i>Arachis hypogaea</i>	Groundnut
<i>Camellia sinensis</i>	Tea
<i>Carica papaya</i>	Papaya
<i>Chrysanthemum cinerariifolium/coccineum</i>	Pineapple
<i>Citrullus lanatus</i> var. <i>lanatus</i>	Watermelon
<i>Citrus limon</i>	Lemon
<i>Coffea</i> L.	Coffee
<i>Eleusine coracana</i>	Millet
<i>Glycine max</i>	Soya
<i>Ipomoea batatas</i>	Sweet potato
<i>Mangifera indica</i>	Mango
<i>Manihot esculenta</i>	Cassava
<i>Musa</i> sp.	Banana
<i>Oryza sativa</i>	Rice
<i>Passiflora edulis</i>	Passion fruit
<i>Persea Americana</i>	Avocado
<i>Phaseolus vulgaris</i>	Bean
<i>Pisum sativum</i>	Green pea
<i>Psidium guajava</i>	Guava
<i>Solanum betaceum</i>	Tree tomato
<i>Sorghum bicolor</i>	Sorghum
<i>Xanthosoma sagittifolium</i>	Taro
<i>Zea mays</i>	Maize

Miseris succurrere disco.

- MacMillan

The more I learn, the more I realise how much I don't know.

- Einstein

Knowledge without conscience is but the ruin of the soul.

- Solomon

Part I: Introduction and Background

Chapter 1 – Introduction

Context of the study

This thesis critically examines issues concerning agricultural intensification and the role of smallholder farmers in Rwanda. The increasing and competing demands for food, water, and energy make agricultural intensification imperative. Leading to a need for production intensification, especially in Africa. Africa is the only continent where the population is expected to double by 2050, and the majority of African farmers have yet to intensify their production using technology and capital-led innovations (Reardon et al. 1997; UN 2015). The growing pressures on land and uneven demographic and economic transitions make the intensification challenge particularly urgent for countries whose economies (and people) largely depend on agriculture. The problem of land fragmentation and small farm sizes are also key issues within research and around policy debates relating to agricultural intensification. Also, producing more food in a world where natural resources are in limited supply implies that agricultural intensification must also be ‘sustainable’ as present day production and intensification should not be at the expense of the food production capacity of future generations.

These concerns are being discussed against a backdrop of ongoing debates about what ‘sustainable intensification’ actually means and what it may entail for millions of smallholder farmers in Africa. However, there seems to be a consensus that intensification is required and that the resulting increases in productivity will be beneficial for the millions of poor smallholding families whose livelihoods rely to a significant degree on farming. The contribution of agriculture to the alleviation of poverty is born out of the logic that helping smallholders to become more productive and commercialised will contribute to increased income generation, better nutrition, and hence poverty reduction. It is a simple yet powerful logic that has driven much of the agricultural intensification and commercialisation discourse since the early 1960s. The devil, however, is in the detail. Despite the well-established argument for sustainable intensification, the sustainable intensification agenda does not yet provide a clear answer as to how smallholder farmers in sub-Saharan Africa can meet multiple livelihood demands sustainably.

Statement of the problem

Many African states envision agricultural transformation as a *sine qua non* for economic growth and poverty reduction. Intensification and commercialisation of both crop and livestock production are therefore at the top of the agricultural agenda. The case of agriculture development in Rwanda epitomises this policy objective. Rwanda has the second highest population density (481.7 inhabitants per square kilometre) in Africa and is one of the most land-scarce countries in the world (UN 2017). Rwandan farmers face an acute land constraint due to high dependence on agriculture and unrelenting population growth, which is further exacerbated by the land tenure regime.¹ In absolute terms, on average, farms in Rwanda are half the size of those in sub-Saharan Africa as a whole (World Bank 2017). Concerning the magnitude of change, cultivated land per capita decreased by 37.5 per cent from 1961 to 2014 (World Bank 2017). Moreover, the majority of the population – and particularly the poor – still rely heavily on farming for their livelihoods. Typically, Rwandan farmers are subsistence-based (79 per cent) and manage on average, less than a hectare of land (80 per cent) (Government of Rwanda 2010). Most of them own some livestock (68 per cent: of which 47 per cent owned cattle, 53 per cent goats and 45 per cent chickens). The staple crops grown vary widely, but most farmers cultivated beans (90 per cent), sweet potatoes (76 per cent), maize (75 per cent), and cassava and potatoes (52 per cent) (GoR 2011a). Thus, given the current constraints on land and lack of economic opportunities outside of farming, agriculture intensification and commercialisation are seen as the only way forward for the agriculture sector and for rural people (GoR 2000, 2002). The Vision 2020 reports that “[c]urrently, Rwanda’s land resources are utilized in an inefficient and unsustainable manner” and “Rwandans can no longer subsist on land and ways and means need to be devised to move the economy into the secondary and tertiary sectors” (GoR 2000: 6, 15). According to the government, “[t]his can only happen through the production of high value crops and modern livestock management. The vision aims to replace subsistence farming by a fully monetized, commercial agricultural sector by 2020” (GoR 2000: 17).

While the logic and reason for advocating agricultural intensification in Rwanda may be justified in broad macro-economic terms, the arguments over how it should be implemented and for which type of producers, remain unresolved and are contested (Ansoms 2008; Booth

¹ Land fragmentation is a feature of the traditional inheritance system. At a coming of age, a young man has a right to ask his father or other family elders for a plot where he can build his own house to farm and to raise a family. As the land passes down from one generation to another, land is divided and shared amongst more people than it had originally been the case (Mfizi, 1983).

and Golooba-Mutebi 2014). The current agenda requires careful examination especially considering that the intensification of agriculture has been the central objective of policy in Rwanda since independence in 1962. Over six decades, one of the dominant approaches to achieving this goal has been through mixed farming,² principally achieved through the integration of crop and livestock production (GoR 1969, 1971a, 1983d, 1991a, 2006). However, despite continued efforts to transform agricultural and rural livelihoods through mixed farming, many farmers do not have the resources required to realise intensification through integrated crop-livestock production (GoR 1974, 1986d, 2004b). Given the imperative of the agriculture sector's contribution to the overall economic development and the reduction in rural poverty, smallholder producers can sometimes feel they are at an existential crossroads. At the crux of this crossroads is the paradox of sustainable intensification. How could a smallholder producer – in particular, one who has limited access to land for crop production and livestock rearing, prioritise and strive for intensification and commercialisation when their current means of production barely covers the household's livelihood demands? The debate over the smallholder intensification and commercialisation agenda in Rwanda warrants a contextually sound and empirically founded analysis.

Against this background, the argument developed in this thesis is that there is a critical disjuncture between the government's vision of modern agriculture based on increasing levels of intensification and commercialisation, and the ability of many smallholders to engage with this agenda. The thesis argues that the disjuncture between this long-standing policy objective and Rwanda's rural realities poses a significant threat to the rural economy and the livelihoods of millions of small-scale producers. I substantiate this argument by studying crop-livestock integration as an element of smallholder intensification in Rwanda.

Aim and scope

This research aims to better understand the dynamics of crop-livestock integration as a sustainable intensification strategy by and for smallholder farmers in Rwanda. Rwanda offers a highly relevant policy, social and natural environment for this study because the issues of land and population pressure are already at centre stage. This research critically engages with the policy agenda that promotes crop-livestock integration as a pathway for smallholder intensification and rural transformation. Thus, this thesis endeavours to answer the following research question: how does the integration between crop and livestock production contribute

² See **glossary** for the meaning of mixed farming.

to agricultural intensification for smallholders in Rwanda? Stemming from this overarching question, I ask the following inter-related questions:

1. (a) How have agriculture and rural development policies developed and changed in Rwanda;
- (b) What are the elements of continuity and change in the policy framing and narratives;
- (c) What lessons can we draw from the historical context and the evolution of agricultural policies and livelihoods that are relevant to the current rural development vision and the politics of agricultural policies in Rwanda today?
2. (a) What is the evidence base supporting intensification through mixed crop-livestock farming as a viable option for the smallholders in Rwanda;
- (b) What are the patterns of crop-livestock interactions and their contributions to both livelihood activities and soil fertility management?
3. (a) What are the pathways or trajectories that led to the observed patterns of engagement with livestock;
- (b) What does the experience of promoting crop-livestock integration tell us about livestock asset transfer programmes and livestock-in-kind development strategies in Rwanda;³
- (c) For whom, and in what circumstances is intensification through crop and livestock integration a potential pathway out of poverty?

The research focuses on family farming. The agricultural system falls into two larger domains of production, represented as the spheres of policy and market forces in Figure 1. The explicit assumption taken here is that besides the endogenous factors such as a family's initial asset endowments and life aspirations, both market and non-market forces influence and motivate the production decisions at the household level (illustrated by the long cross-cutting arrows that link family farming decisions to market and policy spheres). Following are the key concepts that will guide the scope of the thesis.

³ See **glossary** for the meaning of livestock-in-kind.

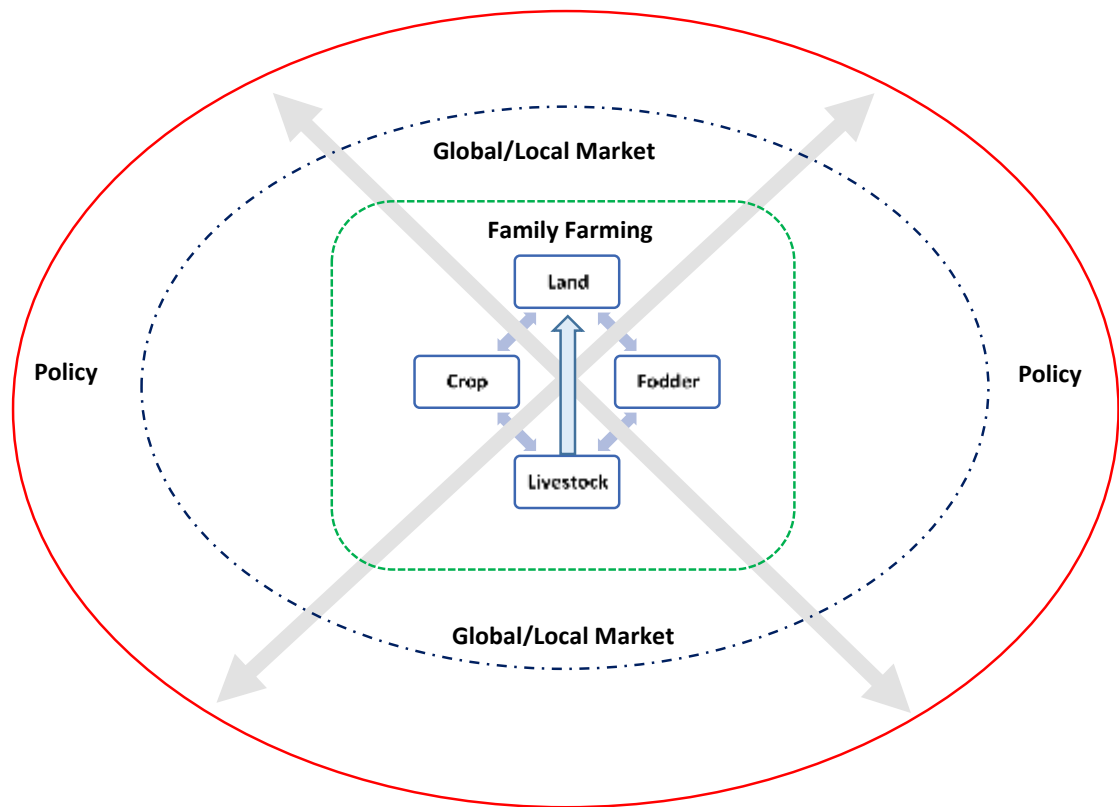


Figure 1. Encapsulated domains of mixed farming production systems

Source: Author's

The smallholder production is the principal subject matter of this research. The terms 'smallholding,' 'small-scale farming,' and 'family farming' are often used interchangeably but depending on the local and agroecological context, their meaning and definition can vary. The Food and Agriculture Organization (FAO) defines smallholders loosely according to agroecological zones: "In favourable areas with high population densities [smallholders] often cultivate less than one hectare of land, whereas they may cultivate 10 hectares or more in semi-arid areas, or manage 10 head of livestock" (FAO 2004). While the characteristics of a family farm and smallholder farm may be similar in the developing world, the distinction becomes much greater in developed countries. For instance, in the United States, family farms are defined as "agricultural businesses where the operator and his or her relatives own the majority of the business" (Lowder et al. 2014: 6). However, beyond the general (and average) farm characteristics, there are a plethora of ways in which agricultural production and family livelihood priorities will be expressed depending on the individual circumstances, seasonality, and market and social conditions.

The relationship between agricultural productivity – defined here as the ability of farm production factors to produce the outputs (Latruffe 2010) – and household livelihood strategies is the focus of this thesis. In particular, to study the interactions between crop and livestock production and their role in intensification and commercialisation processes, the areas of study must be geographically situated where intensification and commercialisation are already present. Therefore, for this research, the presence of vibrant crop and livestock markets (both formal and informal value chains) and agro-processing industry is essential. Wiggins and Proctor (2001) differentiated rural areas into four broad classifications in a development context. The first classification is the peri-urban zone – positioned adjacent to an urban area – which has strong interactions and exchanges between the rural and urban areas. The boundaries between the two are porous and hard to differentiate. The second type is the middle countryside with abundant natural resources, and it has good agricultural development potential. The chances for rural industry development are high if certain policies can correct inefficiencies and ‘make markets work’. The third type is the middle countryside with poor natural resources. These areas have little agricultural development potential, weak market network and a non-farm economy. The remote locations are the fourth category where there are very few known policy options and sustainable development strategies. The people living in the remote areas often require a direct subsidy or social welfare support to reduce the costs of isolation. The variations between the geographical typologies are worth highlighting as the differences in agricultural and market comparative advantages that exist between the peri-urban and rural areas, for example, may lead to different processes of commercialisation and intensification.

Thirdly, the significance of livestock assets in rural poverty dynamics and livelihood strategies is important in this research. Various theories identify farm animals as productive assets that could alleviate poverty and reduce livelihood risks, and even initiating the process of progressive production intensification through livestock-asset accumulation (IFAD 2010; Kabumbuli and Phelan 2003). Enhanced crop-livestock interactions in mixed farming and the ability of livestock to convert lower value and surplus commodities into higher value ones can positively contribute to the household food consumption and diversified income generation (Azzarri et al. 2015). The justification for the progressive asset accumulation and the use of cattle within asset-based development programmes are widely held and practised. Although it is often assumed that a farmer can start with a livestock and grow a herd over time, empirical studies that validate the proof of concept of ‘livestock ladder’ are still sparse (Aune and

Bationo 2008).⁴ In what follows the various attributes of livestock as an asset that fulfil livelihood functions within small-scale farm production are the focus of the analysis for livestock-based asset development.

Significance of the study

This thesis engages with broader debates about intensification and commercialisation of agriculture and the transformation of livelihoods of subsistence farmers. It critiques current agricultural policies as they can at times focus too narrowly on the technical and commercial aspects of productivity and overlook alternatives. Instead, this thesis offers a critical perspective on smallholder production systems and their potential development pathways. A comprehensive fieldwork assessment of smallholder production systems presented in this study contextualises and broadens the empirical knowledge for the less considered and researched production pathways and livelihood strategies that are suitable for small-scale farmers. Moreover, this thesis contributes to developmental theory and practice through deconstructing the notion of livestock as a productive asset and introducing the idea of “asset-ness” – the differential qualities and attributes of an asset – that is crucial in understanding the potential benefits and risks involved in incorporating livestock in mixed farming systems. By doing so, this thesis critically examines the underpinning assumptions of the livestock-based development programmes and highlights the alternative solutions that are more applicable and inclusive to a larger range of smallholder producers in the rural and peri-urban settings in Rwanda.

Overview

The next section provides a detailed review of the conceptual and analytical frameworks used for the empirical analyses in the thesis. To begin with, in chapter 2, I identify the main theories that shape the discourse on the agricultural intensification in Africa. I review how the issues of land and population pressures have influenced the conceptualisation of agriculture productivity and its stages of growth and how this, in turn, has shaped the dominant policy responses. Furthermore, in light of the current gaps in the literature, I problematize the indiscriminate application of crop-livestock integration to smallholder farming systems. In response, I propose the parameters of a conceptual framework that links crop and livestock integration and livestock-based asset development. Chapter 3 details the research design and

⁴ See **glossary** for the meaning of livestock ladder.

methods. I explore various studies found in the literature to examine how other researchers have framed the analysis of farm systems and the methods they used to analyse them. I also explain why the mixed methods approach and integrated analysis using both quantitative and qualitative data adopted in this thesis is appropriate for investigating the research questions. My reflections on the limitations of the field work and the challenges encountered during the data collection offer a critical account of the mixed methods approach. I explain in detail the descriptions of the research participants, choice of study sites, data collection methods and instruments used and the logic and processes of data analyses. Chapter 4 situates the case of Rwanda in the sustainable agriculture intensification debate and establishes the parameters of the argument being advanced within the present study.

Part II presents the empirical findings and discussion. It consists of three chapters. In chapter 5, I use archival material to analyse elements of continuity and change in the policy framing and narratives of the crop-livestock integration agenda. I assess how the current vision of rural development and the preferred agricultural interventions reflect (or neglect) previous experiences. In chapter 6, I present a summary of the two study sites as cases of rural and peri-urban settings. I identify and profile various patterns of interaction between crop and livestock farming found in the field. The household's livelihood engagements using different types of livestock are of particular interest, and the resulting classification provides a contextualised understanding of mixed production systems in the two settings. In chapter 7, I examine in detail the various pathways of crop and livestock interactions observed in the two study sites. The focus of the analysis is the multiplicity of roles and functions of different livestock in smallholder production systems. I also incorporate the life stories of a diverse group of farmers to investigate the factors and key life events that were instrumental in the processes of livestock-based asset accumulation. I highlight the major patterns of engagement of livestock in mixed farming systems and their associated attributes and characteristics. In chapter 8, I bring the findings together to provide a new perspective on agricultural intensification through crop and livestock integration. I also discuss the key issues hindering the scaling up of intensification and commercialisation, and social and cultural complications surrounding the crop and livestock integration in the case study areas. I then discuss the research and policy implications for promoting mixed crop-livestock farming as a sustainable livelihood pathway for smallholder farmers. Finally, this is followed by a conclusion that reflects on the contributions of the thesis and the wider discussion and debate on the sustainable agricultural intensification and the role of smallholders in the future of agriculture in Rwanda and beyond.

Chapter 2 – Review of literature and conceptual framework

The agricultural development agenda in Africa has come full circle. The push for modernisation in the 1960s justified the proliferation of state intervention programmes in the 1970s. At the turn of the 1980s, African governments embraced market liberalisation. In the 1990s the ensuing international commodity price crises gave the opportunity for more bottom-up and participatory approaches that promoted the paradigm of empowerment of farmers and sustainable rural livelihoods. The Millennium Development Goals and the food price crisis in the late 2000s breathed life back into global food security issues and led to calls for more investment in agriculture research. There is also a growing consensus that the state has a role to play in regulating markets and facilitating investments to stimulate smallholder investment in agriculture. Finally, the notion of technology- and capital-led African agricultural revolution came to the fore in thinking about it around the time of the Millennium (Ellis and Biggs 2001; Wiggins 2000). These concerns have persisted into the following decade (Garnett et al. 2013; Pretty et al. 2011).

The key challenge, however, remains unresolved: how can demands of food security and decent livelihoods be met in the face of a growing population, climate change and the sustainability imperative? The conventional answer is to increase agricultural productivity through intensification. Historically, the agrarian transition has meant moving away from subsistence-level farming to highly productive and capital intensive agriculture (Harriss 1982). An example of such transition is the ‘Green Revolution’ that led to significant increases in crop yields. However, due to the differences in social, political, and economic contexts and infrastructural settings, this model of agricultural revolution has not yet been realised widely for African farmers (Dorward et al. 2004; Harris and Orr 2014; Poole et al. 2013).⁵

Nonetheless, the role of agriculture remains paramount in Africa given the general expectation that it is a crucial ‘stepping stone’ or the ‘engine’ of growth, and necessary for kick-starting other economic sectors (Hazell et al. 2010). Before we begin to engage in this debate critically, I first trace the origins of the agricultural intensification theory, critically assess the concepts of

⁵ By ‘this model’, I refer to the massive increases in aggregate food output and productivity per capita achieved during the Asian ‘Green Revolution’ in the 1960s. The development and deployment of high yielding varieties (especially of rice and wheat) were possible thanks to the generous but also focused funding for agricultural (genetic) research programmes and extension service and infrastructural development.

production and agricultural development, and make explicit the underlying assumptions of these ideas.

From land and population pressures to the stages of agricultural development

Malthusian theory

The relationship between the growth of population and economic development is both intimate and complex. The pioneering authority on this subject was Thomas R. Malthus (1766-1834) who launched the population-economic growth debate in his magnum opus 'An Essay on the Principle of Population' (Malthus 1798). He famously argued that the current trends of human reproduction rate (growing exponentially) would outpace the growth of the food supply (growing at an arithmetic rate). He further predicted that if population growth was left unchecked, either politically or voluntarily, the natural course of demographic expansion might lead to famine and catastrophe.

Malthus based his argument on two premises. First, the chances of voluntary control of population were unlikely. Second, the growth in food production will be limited to the rise in labour supply and the fixed land resources, which will eventually lead to a diminishing marginal productivity of labour relative to land and declining wages (Bardhan and Udry 1999: 21; Perkins et al. 2001: 260). Many scholars considered Malthus's theory pessimistic and gloomy. Two crucial and interrelated factors presented challenges to Malthusian predictions: the demographic transition and the power of technological progress and human capital.

The theory of demographic transition posits three stages of development moving in three phases. First there is a shift from a period of high mortality and high fertility to the second phase of a relatively stable population and then through a period of lower mortality with still relatively high fertility. This phase leads to a rapid population growth, but then eventually, the third and final stage of low mortality and fertility, it is argued, brings the population to a new equilibrium (Bardhan and Udry 1999: 20). Despite the negative relationship between national income per capita and aggregate fertility and population growth rate, demographic transition theory is silent on the dynamics and the sources of prosperity and growth and their effect on the population, and vice versa (Shah 1998: 44). In other words, "population growth and income growth influence each other: consequently determining causality through statistical regularities is quite difficult" (Bardhan and Udry 1999: 21).⁶ The classical model of economic growth and the traditional concepts of capital and labour – when applied to food production

⁶ For further reading, see Teitelbaum (1975), Chesnais (1992), and Coale et al. (1993).

and supply – assume that land as fixed. That is, as the population (labour) or capital investment increases against a fixed land resource (i.e. nearing the land's carrying capacity), the law of diminishing return mean ever diminishing gains in marginal productivity.

What the economists at the time did not know (or took little into account) was the potential of technological innovation.⁷ The quality of the labour force and the advances in the sciences and technology affirmed the importance of 'human capital' in surpassing the effects of diminishing returns to investment (Knight 1944). In fact, the economic value of human agents proved to be more important to increasing productivity than all the non-human capital combined (Schultz 1993). Also, technological progress in the agriculture sector continued to outpace the effects of diminishing returns and the population booms in the post-World War 2 era. The discovery of new resources and more efficient use and improvement of existing resources, helped sustain the income and economic growth of the industrial economies. Therefore, the effect of population growth on economic development could either be positive or negative. The rise in population could be economically beneficial "[t]o the extent that increasing returns to scale underlie growth", or negative if the effects of fixed resources and diminishing returns outpace the countering measures of technological progress and innovation (Bardhan and Udry 1999: 21).

Boserupian theory

Ester Boserup (1910-1999) challenged the inadequacy of the Malthusian theory when applied in densely populated agrarian economies of the South and Southeast Asia. During her extensive field work in India (1957-60), Boserup found empirical evidence that gave her the reasons to question the Malthusian theory and the conventional economic wisdom. In 1965, Boserup published her book '*The Conditions of Agricultural Growth*', which was less than enthusiastically received by her fellow economists. Quite controversially at the time, Boserup argued that the population growth acted as a stimulus for innovations in intensive land use and farming technology. This became known as the induced innovation for agricultural intensification (Boserup 1965; Ruttan and Hayami 1984). She proposed that "[a]ny given area will go through a series of increasing land use intensity under the spur of population growth" (Grigg 1979: 67). For instance, when population densities are low, there is enough land available to grow crops and to use natural fallow.⁸ With rising population densities, however,

⁷ Shah (1998) rightly pointed out that "Malthus allowed for some technological improvements to take place. But his microeconomic analysis implied that such technical change would lead to increased reproduction and so, in the long run, its benefits would be soaked up" (p.41).

⁸ See **glossary** for the meaning of fallow.

the fallow periods shorten to allow for more frequent crop cultivation. At the final stage of the rise in population density, fallowing stops. The frequency of cultivation would increase as much as the soil fertility and water availability via irrigation or rainfall would allow. Also, more than one crop would be grown on the same field, yielding more output per unit of land (sequential cropping or intercropping).⁹ Therefore, instead of using fallow to restore soil fertility, farmers must find alternatives and also address other issues that can arise from more intensive cropping such as the occurrence of diseases and pests, and competition for resources. The transition from subsistence to intensive cultivation, thus, requires better practice, technology and tools and equipment (mechanisation), but also, more privately-secured land tenure and settlement arrangements (Boserup 1965).

By identifying agrarian systems along the scale of population density (from low to high) and the intensity of production (from extensive to intensive), Boserup's theory has inevitably been associated with a view of the agrarian transition as a progression of stages of agriculture intensification. The sequential progression of farming intensification is seemingly 'evolutionary' – in the sense that each stage of growth requires an upgrade from 'traditional' to 'technological' means of production. For instance, "the hoe replaces the digging stick, and later the plough ousts the hoe" and "the changes in land tenure and settlement patterns [develop gradually] from shifting to permanent settlements, and from communal tenure to individual ownership" (Grigg 1979: 67). Consequently, for better or for worse, the evolutionary concept has reinforced the dichotomous and ordinal positions between the traditional (subsistence, little market orientation) and modern (commercial, technological) practices of agriculture. The evolutionary metaphor of agricultural change has since influenced and continues to drive the agricultural intensification debates and studies (Jayne et al. 2014; Perrot et al. 1995; Pingali et al. 1987; Ruthenberg 1971; Ruttan 1989).

Conceptualising production, agricultural productivity and farm systems

In the previous section, I presented the theories of Malthus and Boserup as the underpinning paradigm that led to the current hegemony of modernisation within the agriculture development agenda. By doing so, I established the theoretical basis of why and how agricultural intensification is conceptualised as it is today. However, there is also a need to deepen the understanding of the processes of change and the outcome of agricultural

⁹ See **glossary** for the meaning of sequential cropping and intercropping.

development especially in relation to agricultural productivity and production, as these are the core issues within the intensification debate. In the following section the fundamental ideas of production and agricultural productivity are defined and developed. The difficulties of applying these concepts in empirical studies is then considered.

Production and productivity

In its generally used sense, the term productivity is “the state or quality of being productive” (OED 2017) or as Latruffe puts it “the ability of factors of production to produce the output” (Latruffe 2010: 18). To grasp the meaning more clearly, the focus must be on the root word: production. The Oxford English Dictionary defines production as “the action of making or manufacturing from components or raw materials, or the process of being so manufactured” (OED 2017). This definition is somewhat ideologically limited as it omits the centrality of human labour to the process of production. The modern sense of production stands quite far off from its original meaning. The word ‘production’, originally derived from the Latin verb *producere*, means ‘to stretch’, ‘to spend’, ‘to prong’, or ‘to draw into visibility’: i.e. bringing something hidden into manifestation or “an actualisation of possible existence” (Robert 1997: 195). The ancient meaning of the term, therefore, captured the essence of the “ordinary people’s experience [:] the awareness that nature, husbanded by man, brings forth a people’s livelihood” (Robert 1997: 196). In the modern era, however, the meaning of production morphs into the economic and technical concept where people become the ‘producer’, and the ‘product’ takes on a new entity and value (Robert 1997: 198).

In *The Wealth of Nations*, Adam Smith (1723-1790) propounded the principles of free market theory and the ‘division of labour’ as the key factor in the creation of wealth (Smith 2013 [first published in 1776]). Hence, classical free market economic theory places the organisation of human ‘labour’ as the cornerstone of the modern world’s notion of production (Robert 1997: 199). David Ricardo (1772-1823) followed suit in advancing the ‘labour theory of value’ in his *Principles of Political Economy and Taxation* (Ricardo 1973 [1817]). Again, in line with Smith’s notion of labour, Ricardo defined “the value of a commodity, or the quantity of any other commodity for which it will exchange, depends on the relative quantity of labour which is necessary for its production” (Ricardo and Sraffa 1955: 11). Ricardo popularised many theories concerning rent, wages, and profits, but chief amongst them was the ‘theory of comparative advantage’ (Ricardo and Sraffa 1955: 44). According to Ricardo, the differences in the cost of production (labour being one of the most important factors) between the countries provided a compelling economic incentive to engage in international free trade. In a simple two-country free trading example, Ricardo demonstrated that there are gains to be made (and to exploit)

from each country's differences in the quality of its labour productivity and technological progress (Ricardo 1973). Therefore, by equating "welfare and wealth with exchange value production could now be understood as a purely human creation – resulting in exchange value and its expression in money – on which everyone would be dependent for survival" (Robert 1997: 200).

However, 'survival' or 'subsistence', in the economic sense of the term, is at odds with the modern principle of production – i.e. "[f]rom the economic standpoint, a subsistence mode of living is not viable" (Robert 1997: 205). Thus, labour productivity and the costs of production became the driving forces of free trade and the global market economy. Moreover, modern capitalist production puts the burden on the labourers so that a unit of work should not only satisfy the immediate consumption needs but is also expected to generate 'surpluses'. Karl Marx (1818-1883) developed and explained the 'theories of surplus value' and the 'labour theory of value' in *Capital: Critique of Political Economy* (Marx 1906 [1867]). In theory, the differential production relations between countries may increase the overall consumptions for the society as a whole. However, there was an imbalance between trading nations. The 'original accumulation' of wealth and capital of the West incorporates and carries the histories of their violent conquest of indigenous peoples, their culture, land and natural resources. The subsequent legacy of colonial exploitation and post-colonial diplomacies continue to distort the trading terms and conditions negotiated between the early industrialised and the developing nations (Chang 2002; van de Walle 2001).

The concepts of production and productivity in agriculture are mainly concerned with the science and techniques of measurement. Typically, agricultural productivity is a measure of the ratio of agricultural outputs such as the quantities of crop produced in relation to inputs of, for example, labour and capital. Productivity measurements can be partial such as relating output to one particular input such as land, or total such as aggregating all the outputs to all the inputs. However, taking into account of all the factors that go into the agriculture production system is both analytically and technically complicated [see, for example, de Vries and de Boer (2010)].

Latruffe identified three broad ways in which productivity improvements could be achieved (2010). Firstly, by more efficient use of the available resources and existing technology. For instance, planting fodder grass on the edge of a crop plot or inter-cropping leguminous plants in alternating strips with cereal crops to allow farmers to harvest multiple products to satisfy various household and livestock feeding needs.

Secondly, through the economies of scale, that is, by leveraging “the ratio of the proportionate increase in output to the proportionate increase in all inputs” (Latruffe 2010: 19). In other words, economies of scale in farm production mean the “ability of a farm to lower costs of production by increasing production” (Duffy 2009). Examples of economies of scale in the agriculture sector are monocrop production on consolidated land and replacement of labour through capital investment in mechanisation.

Lastly, it is possible to reach a higher productivity frontier through the advances in technology and innovation such as genetically modified crops. Technological progress in the livestock vaccination for endemic diseases such as bovine brucellosis, for example, could enhance milk production and weight gain, decrease chances of calf mortality and boost fertility and successful pregnancy – all contributing to the increases in overall cattle productivity (USDA 2015). Such technology – in this case, the vaccine against the group of *Brucella* bacteria species – is inherently ‘neutral’ in the sense that it can protect all cattle, no matter how large or small the herd.

However, what is not ‘neutral’ in the deployment and adoption of technology is that the owners or managers of the cattle do not have the same access to the technology, resources and information. Therefore, assuming that the technological progress would apply equally to all producers would miss this crucial socio-economic factor. However, as mentioned before, measuring productivity improvements of efficiency, economies of scale and technological progress is conceptually and empirically challenging. For instance, there are factors of production that are not observable because they are intangible, such as the farmer’s management capacities and the social capital where one could only estimate their proxy values (Latruffe 2010: 36). Moreover, there are various determinants beyond the farms’ immediate control that affect the household's productivity and resource allocation decisions. For instance, the broader spheres of influence include government interventions and regulations in the agricultural sector; public expenditures in research, extension and infrastructures; and the locational and environmental characteristics such as the soil quality of a particular farm under consideration (Latruffe 2010: 37-43).

While the theoretical understanding of production and productivity has changed significantly with the advances of the industrial and global market economy, smallholder farming in the developing world has remained diversified and complex, which does not readily conform with the (neo)classical economic assumptions (Ellis 1993; Shanin 1973). Clearly, there is a need for a broader enquiry and improving the definitions of efficiency and productivity in the smallholder farming context as well as developing more operationally practical methods to measure them.

In the literature, one of the most prominent analytical frameworks used to conceptualise agricultural intensification is that of farming systems. Seeing through the family farming systems model helps to focus our understanding of the components and forces within the interrelationships between the natural environment and the social institutions such as the market, household and the government through their policy interventions.

Farm systems

The concept of a system is one of the most widely adopted and used analytical frameworks in science. General system theory was first introduced by Ludwig von Bertalanffy (1938) in response to the need for clear theoretical laws in the field of biology. In particular, the rapidly growing science of empirical and experimental embryology lacked a conceptual framework that could explain a living organism as a whole – as a ‘unitary system’ – and the embryonic development as a function of the whole and not as a sum of cell-functions (Bertalanffy 1938). Since then, the systems theory gradually gained popularity in the 1950s and adopted in other disciplines such as organisational management, psychology, sociology, and economics.

The search for a general structure and order in complex social settings also gained traction in the social and agricultural sciences. During the 1970s and 1980s, agriculture scientists and development economists postulated a farm systems framework (Bourgeois and Sebillotte 1978; Jouve 1986; Reardon et al. 1988). Bourgeois and Sebillotte (1978) conceptualised the farm systems as three overarching and interrelated components (but each part could be considered a system of its own). The ecosystem is the first element, and it forms the basis in which a series of farm production and family (livelihood) management decisions could be derived and analysed in multiple scales. Secondly, the soil and climate influence the plants’ yield through soil nutrient absorption and photosynthetic performances at the microscopic scale. The family and livelihood management is the third part of the farm system. Family farming and livelihood decisions are strongly correlated and influence each other. For instance, farmers constantly reassess on a day to day basis the market sales and food consumption choices and also prioritise the long-term strategies of either sending the children to higher education or keeping them at home for family farming (Jouve 1986).

The three pillars of the farm systems are connected and driven by various socioeconomic and agroecological factors and forces. The strength and the direction of the connections between the systems balanced each other as an equilibrating mechanism where various regulating factors moderated the interactional flows from one component to another. Such a system could function in a myriad of ways, but essentially, the format is the same: a diagram with a

collection of boxes and connecting arrows demonstrates the structural and functional roles of each component (Figure 2).

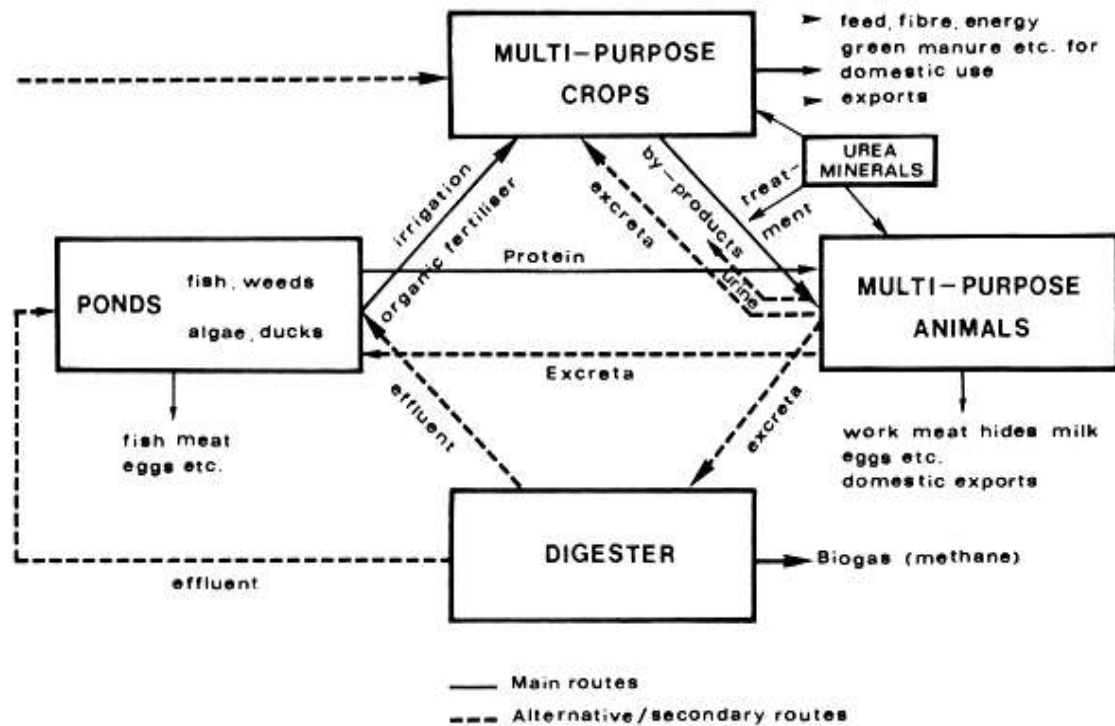


Figure 2. An example of the integrated farm system for agriculture, livestock and energy production

Source: Reynolds (1995: section 9.5.1)

What is not illustrated but implicitly assumed in the diagram is the technological innovation and the changes in socioeconomic conditions and policy that drive the transformation of farm production systems. According to the theory of induced innovation, technical innovation is the critical response and outcome to the increases in population density and land use (Ruttan and Hayami 1984). It is the precondition for initiating the transition from subsistence to high production intensification of farm systems. Also, there is a clear hierarchical order in the trajectory of the agricultural production systems from low to high and from backward to modern.

In the following sections, I explore this notion of 'evolutionary' stages of growth and development in agriculture that dominates the intensification and crop-livestock integration debate in sub-Saharan Africa. I review the two prominent schools of thought. The first (and the dominant) strand of literature frames agriculture intensification and rural development on an evolutionary trajectory where production systems gradually evolve from extensive to intensive forms according to the agroecological adaptation, technological innovation and commercialisation. The second is a critique of the first, and propose a more locally and socially

contextualised and targeted approach to tackling the agricultural intensification challenges. But first, we need to establish the definitions and introduce the concepts of ‘mixed’ farming and crop and livestock integration.

Mixed farming and crop-livestock integration

Making sense of mixed crop-livestock farming

Mixed farming is a term that is widely used in the agriculture literature to refer to various forms and practices around the world. While the general definition of mixed farming is relatively straightforward – farming that integrates crop and livestock production – different types of mixed farming are sometimes categorised based on the land size, type of crops and livestock, geographical location and market orientation (FAO 2001). First of all, what is meant by ‘mixing’ in farming? At the spatial level, mixing can occur across distance (such as with the exchange of productive resources between distant and un-associated farms) or within the individual household farm unit (such as sharing of resources across different production modes of crops and/or animal farming in situ and on-farm) (FAO 2001). In temporal scale, mixing can happen across seasons as happens during post-harvest gleaning and tethering arrangements between nomadic pastoralists and sedentary farmers or it can happen concurrently such as with intercropping where shade-grown coffee plants lie under a canopy of trees.

At the farm level, mixing of different crops and animal management practices can happen either exclusively or inclusively. In the ‘exclusive’ mixed farming, there are no linkages between the crops and livestock production systems: they are independent of each other. For instance, the mixed cropping (only) strategy may involve cultivating multiple and/or intercropping (grain-legume rotation). As for the ‘exclusive’ mixed animal rearing strategies, farmers may keep different types of animal for complementary purposes such as are found with chicken and fish pond production systems in Asia. In this research, however, the focus is on the integration of crop and livestock production systems. Therefore, the exclusive production systems are beyond the scope of the thesis.

In comparison, ‘inclusive’ modes of mixed farming at the on-farm level allow mixing and sharing of productive resources between crops and livestock systems. For example, the soil nutrient recycles through the links between animal feeding on plant biomass and organic manure returning and fertilising back the field. This type of mixed farming represents the biological or nutrient integration between crop and livestock production systems. Rather confusingly, there is an additional level of classification that distinguishes between integrated and non-integrated (or ‘diversified’) systems (FAO 2001: Ch.2). For instance, in a non-

integrated systems, crops and livestock can coexist independently from one another without exchanging and recycling productive resources. In this case, the integration between crop and livestock productions are financially motivated where the primary goal is to minimise risks and to mix income generating activities (IFAD 2010). The distinction gets muddled, however, if the income generated from one of the production systems feeds into the other production system. For example, the farmer may use the revenue generated from the intensive dairy production to purchase chemical fertiliser and improved crop seeds, which will positively contribute to the crop production system. The cross-linkage in this case, however, is limited in the form of capital investment generated from different production systems (the same reasoning can apply for remittances), and therefore, in this thesis, I will consider such cases as financial (livelihood) integration as opposed to biological (nutrient) integration.

Within the integrated systems, there are different types and levels of resource exchange and interactions. Schiere and colleagues deduced five characteristics of mixed crop-livestock farming (FAO 2001; J. Schiere and Nell 1993; J. B. Schiere and de Wit 1993).

- Sources of animal feed (infield, outfield, roadsides, import)
- Importance of animal excreta (dung and urine)
- Source of farm labour energy (human and mechanic versus animal draught power)
- Importance of crop residue feeding
- The role of animals as functional livelihood assets such as savings account

Except for the source of farm labour energy,¹⁰ these characterisations will serve as the guiding parameters of crop-livestock integration assessments for the empirical analysis.

The dynamics of agricultural intensification and crop-livestock integration

The evolutionary model of crop and livestock integration

Since the end of the Second World War, technological innovation in the agriculture sector provided a solution for the rapidly growing population. This resulted in rapid gains in productivity, efficiency and yields. One of the consequences of many of the gains achieved in productivity, however, was extensive negative environmental and social impacts creating global concerns around the degradation of ecological habitat and species and soil and water pollution, which some argue potentially places human health at risk (Carson 1962). The growing concerns over conventional methods of production and the need for alternative ways

¹⁰ Rwandan farmers do not use animal draught power. One of the reasons is that the soil compaction is weak on hilly terrain, and therefore, the surface is susceptible to erosion. Thus, farmers consider careful hand hoeing work more beneficial than ox ploughing. Therefore, I have omitted animal labour energy in the analysis.

to produce more with fewer resources have ushered a significant shift in the research agenda, namely the study of ‘sustainable agricultural systems’ (Clive A Edwards 1989; Clive Arthur Edwards et al. 1993). Generally, the sustainable farming systems aim to “minimize energy-based chemical inputs, produce good yields, increase farm profits and decrease environmental problems” holistically (Clive Arthur Edwards et al. 1993).

Depending on the type and degree of integration, mixed farming can take varying forms, methods and strategies for producing crops and rearing livestock. But the mixed farming or the integrated crop-livestock systems are promoted as a variant of the sustainable agricultural systems. Whether they are sustainable, where and in what form, is an empirical question. There is nothing inherently sustainable about mixed farming (Sumberg 1998). A further example of the mechanism of ‘integrated crop-livestock systems’ is where “crop and livestock production activities are managed by the same economic entity, such as a household, with animal inputs being used in crop production and crop inputs being used in livestock production” (Williams et al. 2000: 132). This mechanism is an example of the integration of nutrient cycling at the household/farm level, but the spectrum of integration ranges from the micro- (e.g. plot) to the more macro- (e.g. regional) scale. Grazing rights, pasture and land degradation management are examples of a broader and higher scale integration at the community level (FAO 2011a).

At the conceptual level, the concept of integrated crop-livestock systems and the Boserup’s stages of agricultural growth merge to become the general model of the evolution of crop-livestock interactions. The model posits that “the choice between [the] specialised production of crops and livestock and some integration of the two” are influenced by the effects of agroclimate zonal comparative advantage, population density, markets and exogenous technologies (McIntire et al. 1992: 23). There is a clear demonstration of the evolutionary tendency in their conceptual model. McIntire and colleagues (1992) describe seven stages for the crop and livestock interactions in Africa south of Sahara:¹¹

1. At low population density, crop and animal production are ‘extensive’, they use more land per unit of output than do ‘intensive’ techniques. Extensive agriculture creates few interactions, and those interactions which occur do so through markets or contracts among highly specialised producers of crop and livestock.
2. With low population density and extensive production, there is a cost advantage to specialising in crop or animal production and interacting through markets and contracts.

¹¹ The italicized emphases are added and are specific to this study.

3. *Agriculture intensifies in response to population growth and changes in markets. Intensification means that farmers use more animal power, manure, and crop residue per unit of land and output. Where new markets or technologies create opportunities for growth, intensive agriculture is stimulated further.*
4. Within agroclimates favourable to ruminant animal production, intensification of farming affects land allocation to crop or livestock production by location and season, stimulating further interactions between herder and farmers.
5. *Greater interaction occurs in a progressive response to the main intensifying forces. Increasing constraints to obtaining inputs in markets or contracts are associated with closer interactions. Such constraints create cost advantage in providing inputs directly on farm, thus encouraging crop-livestock integration. This movement to mixed farming occurs almost exclusively when extensive techniques of soil fertility maintenance cannot meet the crop production demands made by rising population.*
6. While population growth aggravates competition between crops and livestock, it does not begin to limit livestock production until fairly high human population densities. *This is because the main constraint to livestock production is dry season feed, which is more binding than land competition from crops in the wet season.*
7. *If the market and exogenous technologies develop, there can be a movement away from integration and a return to specialisation. This movement is due to technical changes – fertiliser replacing manure, tractors supplanting animals, supplements replacing crop residue and pasture – which eliminate the cost advantage of a mixed enterprise providing its own inputs.*

The visual representation of the stages of agricultural intensification development captures the logical framework of the theory well (Figure 3). On the horizontal axes, two related factors are moving in the same direction such that when the population density rises from low to high (bottom axis), the competition for resources (natural and social) will also increase from low to high (top axis). In response to these pressures, farm production will first grow extensively, and then intensively (shown in the vertical axis). The areas and the activities related to crop and animal production (shown as triangles at the bottom left corner of the diagram) are at first independent of each other. They eventually overlap when the environment and market conditions are conducive for, and the technologies facilitate the crop and livestock production integration (overlaid triangles shown as a cross-hatched square in the middle). Greater forces of population growth and resource competition will again separate the two productions at the final stage of the intensification as production specialise (two triangles at the top right corner).

The neat, linear, and step-wise progression of the crop and livestock interactions reveals a compelling narrative of evolutionary stages of agricultural growth. That is, the evolutionary laws of the modern society depend on the innovation in science and technology to lead the market growth and development, which will ultimately address the perennial question of the

‘Malthusian trap’.¹² While it is not explicit, the underlying assumption of this narrative frames the transition from low to high productivity per capita – from subsistence to market-oriented agriculture – as a quasi-scientific law or a higher ‘natural’ order similar to the evolutionary paradigm. Such a framing is helpful for a particular understanding of a system, but it also raises questions when generalised.

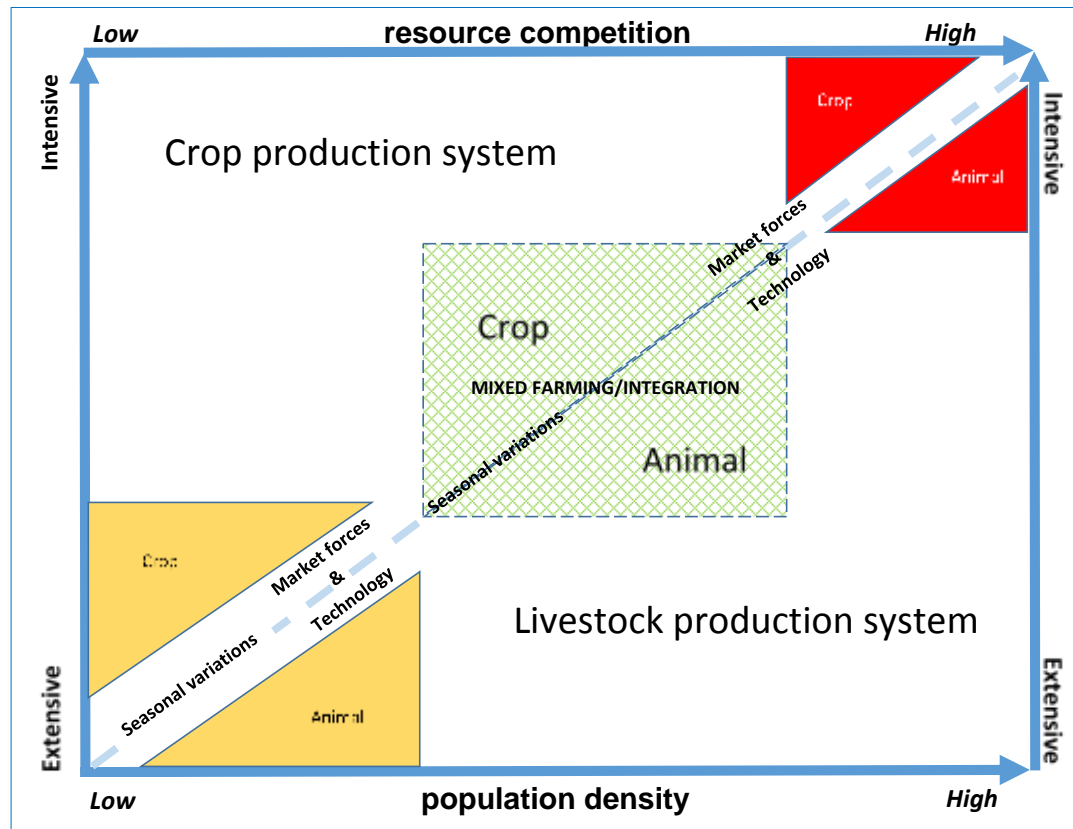


Figure 3. A diagram of the evolutionary model of crop-livestock interactions

Source: Author's adaptation from McIntire et al. (1992) and Williams et al. (2000)

A multiple pathways approach

Scoones and Wolmer challenge this ‘evolutionary’ approach to agricultural change arguing that the “assumptions embedded in a deterministic, linear evolutionary views lead [...] to inappropriate policies and technical solutions” (Scoones and Wolmer 2002: 5). The authors challenge the evolutionary paradigm on three grounds. Firstly, the idea of ‘evolution’ assumes ‘progress’ and ‘autonomous intensification’, presenting agricultural intensification as a natural process of change “from primitive agriculture towards higher levels of technique and cultural development” [Boserup (1965) cited in Scoones and Wolmer (2002: 21)]. The basis for the general agricultural development modelling which aims for a simplification of complex and

¹² See **glossary** for the meaning of Malthusian trap. Cf. Malthus (1798) and Shah (1998).

dynamic processes of a generalizable and representative model, verges more on to the natural (more easily objectified) than the social differentiation (more heterogeneous, co-relational, and contextually different). Consequently, the crop-livestock integration model narrowly assumes a single and deterministic pathway of change based on the agroecological settings. Such a linear approach invariably creates 'higher' and 'lower' stages of production which carry positive (modern, efficient and sustainable) and negative (backward, inefficient, and unsustainable) connotations, respectively (Scoones and Wolmer 2002: 12). While spatial conditions are an important aspect of the framework, other scholars have critically argued for factoring into the analysis and discussion historical contexts and social processes to help explain the process of change in the mixed farming model (Tiffen et al. 1993; Tiffen 1994).

Secondly, the evolutionary model of crop-livestock integration ignores the multiple pathways of agricultural change and discounts the diversity and variability of people's intrinsic values, talents, and production goals and the associated livelihood contexts. For instance, one of the major benefits of integrating crop and animal production is the use of organic manure for improving soil fertility. The optimal use of manure, however, is limited by the individual farm household's capacity to efficiently handle, store and apply it. Moreover, the relative value of using animal manure must be factored against the availability, accessibility and affordability of other alternatives such as mineral fertiliser, green manure crops and incorporating nitrogen fixing plants and trees. The differences in knowledge, attitudes and practice of manure application can vary widely even within a similar agroecological and climate zone, which also affect the household's decisions about manure use (Kim et al. 2013). Problems arise when modes of economic organisation and certain production strategies are universalised, leading to the extrapolation of highly sequential stages of production to explain the structure and processes of agricultural intensification (Morrison et al. 1996). Thus, the picture will not be complete without carefully considering the context of the local livelihood options and activities, and variabilities in the individual's capabilities and capacities for production.

The third critique is that the conventional approach based on the agricultural economics perspective to the mixed farming model often "fail to examine the underlying social and institutional processes of change" (Scoones and Wolmer 2002: 22). One reason for the omission is due to the dominance of technology in the international research agenda and funding. The technocratic bias of the mixed farming model is common in the extensive body of grey literature (FAO 2011c, 2014; OECD 2006). Unfortunately, the narrow understanding of the trajectory of agricultural change and the over emphasis on the technical aspect of interventions, at the expense of overshadowing other influential social and historical factors,

can be a detraction. The agricultural intensification model which operates upon a presumption of being technology-led, was but one of the many pathways of transformation observed from various case studies from Ethiopia, Mali and Zimbabwe. What is more, the sequential nature of the intensification process was not a norm, but rather an exception, as it only occurred under certain conditions. Scoones and Wolmer therefore concluded that the trajectory of changes in farming systems “does not always happen smoothly, gradually, [nor] predictably” (Scoones and Wolmer 2002: 22).

The question may be asked why the ‘evolutionary model of agricultural intensification’ has become so dominant. One response might be that the evolutionary model appeals to policy planners because it gives a sense of order: there are ‘clear’ stages of development (Tiffen 1995). Moreover, in practical terms, the mixed farming framework could be easily adapted to actionable interventions, and policy guidelines as many of the farmers already own livestock. Alternatively, Scoones and Wolmer propose a new multiple pathways approach for crop-livestock integration that takes into account agroecological and livelihood contexts; history and the dynamics of change; social differentiation; and institutional processes (Scoones and Wolmer 2002: 23-9). As they pointed out, “narratives and paradigms die hard” and “[t]here is always a powerful urge to simplify complexity” (Scoones and Wolmer 2002: 208). However this leaves unanswered the question of how to introduce the impetus that will shift in a direction away from the status quo? One concrete suggestion they make is “to document diversity” (Scoones and Wolmer 2002: 208). However, even a decade and a half since the introduction of the alternative framework, the crop-livestock production debate is still mostly a proposition of the single policy narrative and the default of the modernisation and evolutionary paradigm. In what follows there is a consideration of the current gaps in the literature. This discussion seeks to problematize the assumptions surrounding the notion of mixed farming and the idea of integrated livestock-based development.

Problematizing the debate

Having reviewed both the dominant and the alternative concepts of crop-livestock integration, there are several points of convergence and divergence within the debate. As a starting point, most scholars studying this issue agree that the productivity-led smallholder agricultural growth is desirable for both the people (food security) and the government (economic development). The intensification of agriculture, whether it is sustainable or not, is widely accepted as the solution to alleviating household food insecurity and rural poverty (Barrett 2008; Dorward et al. 2009; Fan et al. 2013; Niehof 2004; Pretty et al. 2011). Many researchers support the case for the mixed farming approach, using livestock as a productive livelihood

asset for areas where arable land is limited, and population stress is high (McDermott et al. 2010; Powell et al. 2004; Tarawali et al. 2011; Winter and Doyle 2008). The increasing demand for livestock products in developing countries – driven by growing population and consumer power (Godfray et al. 2010) – also adds weight to the argument that with the growing market opportunity, smallholder producers have a role to play in meeting this demand (Delgado et al. 2001; Sumberg and Thompson 2013; Upton 2000). This raises the question of how we can bring a practical and affordable (technological and social) transformation into small-scale production systems.

Is it the case however that 'mixing' is always an improvement to smallholder farming systems? The mixed farming strategies have advantages and disadvantages (FAO 2001). On the positive side, combining and reusing resources can help reduce production risks and improve resource use efficiency such that farmers can cost effectively achieve an optimal level of resilient production. A possible negative is that the division of resources and labour to accomplish multiple tasks limits what can be achieved through specialisation for economies of scale. The cost and benefit profiles of a mixed farming system depend on “the sociocultural preferences of the farmers and to the biophysical conditions as determined by rainfall, radiation, soil type and disease pressure”, and therefore, “mixing of several parts requires a special approach to make a success of the total mix” (FAO 2001: 3). In other words, the need for and the effect of crop and livestock integration varies to different farming households because they face individual and diverse conditions and capabilities related to production.

It is also worth highlighting that integration is not always a voluntary option nor does it always lead to an improvement (FAO 2001). Smallholder farmers who have limited access to and ownership of assets and resources may not necessarily wish to choose mixed farming: that is, not by choice but out of necessity. In such circumstances, the lack of capital and investment to purchase other supplementary inputs such as chemical fertiliser and improved animal feed may eventually exhaust both the environmental and social capital to an unsustainable level. Classic examples of such over exploitation of the resource base are soil nutrient mining (Henao and Baanante 2006; Smaling et al. 1993) and collapse of communal grazing land (Abel and Blaikie 1989). Certainly, we need more studies that go beyond the usual identification of constraints and prescription of technical solutions, but rather, raise the inconvenient issue about why such solutions are out of reach for many and how we can make these solutions more affordable and accessible.

There is also the claim that livestock is a useful asset for poor people, especially women, and can, therefore, play a central role in poverty reduction and economic empowerment (Alary et

al. 2011; LID 1999; J. Njuki and Sanginga 2013). This idea builds on the assumption that poor people can gradually build up the herd of, for instance, small ruminants and through progressive accumulation, work their way up to more valuable livestock such as cattle. While this notion of a 'livestock ladder' provides an intuitive explanation of the various return-potentials of different livestock production systems the process of how poor smallholders can and will start climbing such a 'ladder' is unexplained in the literature.

There are two issues about the livestock ladder that are problematic. The first is the naïve assumption of 'autonomous intensification' (Lele and Stone 1989) and 'natural increase' of a herd (Ferguson 1985). Considering the multiple functions and particular roles livestock play in the smallholder livelihood context, not to mention the high rates of mortality and poor rearing conditions that keep rates of reproduction low in the rural areas – increasing the size of the herd would be more of an exception than the norm. The second issue is according to cattle, especially dairy cows, the position and status of the highest development asset for smallholder farmers. The men's (to be gender specific) obsession with cattle – also known in the literature as the 'cattle complex' (Herskovits 1926) – has a long historical lineage. This fixation continues and is reciprocated in the contemporary institutions by both the locals (see Ferguson's (1985) thesis on "the bovine mystique" in Rural Lesotho) and international interest groups alike (Winrock International 1992). The overwhelming focus on a particular species in the livestock research and development agenda is apparent in the literature but rarely questioned. Moreover, the over emphasis on the bovine-centric integration of crop and livestock production may result in "a minimisation of the importance and potential of other pathways for the intensification of livestock production" (Gass and Sumberg 1993: 5). But also, the cattle-based integration pathways will most likely be out of reach for the people with limited access to high-quality land and other productive resources. Understanding these alternative pathways of intensification of livestock production may be more relevant and vital as a diversifying livelihood strategy for the marginalised groups of farmers.

The literature indicates that many supporters of sustainable intensification have technocratic tendencies similar to those of conventional agriculture planners. Some observers have an unrelenting optimism about sustainable intensification through crop and livestock integration (Lemaire et al. 2014, but for counterargument, see Franke et al. 2010). Consequently, even the alternative solutions suggest a perpetuation of a host of interventions such as developing high-yielding forage legumes and leguminous tree crops, improving the quality of crop residues, improved pasture management, and improved feed harvesting and storage to preventing nutrient losses (Scoones and Wolmer 2002: 14).

This viewpoint persists despite awareness that even with the enhanced benefits of the crop-livestock integration, an enclosed mixed farming system will eventually cease to be 'sustainable' if the yields are expected to increase annually over a long period of time. Therefore, beyond its circumscribed means of regeneration, endless intensification of production will require the additional external inputs and support to correct the negative balance in soil nutrients. The problem being raised here is not concerned with the technological aspects of sustainable production but rather the misplaced and unrealistic expectation of what sustainable intensification should accomplish.

Despite the gaps in the conceptual frameworks, many developing countries in Africa have adopted the 'agricultural intensification through integrated crop-livestock farming' rhetoric and have implemented policies in support of the mixed farming agenda. One of the reasons for this political buy-in is thanks to the powerfully simple conceptual representation of a complex system. The evolutionary model of agriculture development is intuitive and thus, remains currently the most widely adopted narrative and vision amongst the development agencies and governments (Cochet 2012; Grove and Edwards 1993; Klapwijk et al. 2014).

Understandably, the idea of situating different farming systems on an evolutionary trajectory helped demarcate and prioritise the types of intervention and resource allocation more conveniently.

The farm systems framework opened new ways of thinking and framing the complex problems of contemporary agricultural science and practices. However, there are many assumptions in the family farming systems that need thorough investigation. For instance, many scholars have taken a critical stance against the 'modernist' agenda for poverty reduction and rural development (Dawson et al. 2016; Huggins 2013). Instead, they call for an interdisciplinary research approach focusing on the dynamic livelihood interactions arising from the complex, diverse, and risk-prone environments where the rural people living in poverty are commonly found (Thompson and Scoones 2009). The complexity and heterogeneity in farm systems analyses are not only defined by the physical laws of nature but more so on the dynamic interactions between the human and environment and the potential pathways for agrifood systems (Scoones 2009). Therefore, the diversity and the complexity of the rural livelihood interactions and relationships must be recognised and contextualised according to the various geographical factors that reflect the differential endowments of tangible (natural) and intangible (social) resources (Wiggins and Proctor 2001).

Despite the strong appeal for more interdisciplinary research in the literature, however, the agricultural development studies conducted in sub-Saharan Africa have been primarily focused

on the economic aspect of development and on improving quantitative productivity and yields. However, research focused mainly on food productivity and economic gains gives an incomplete understanding of the rural reality. Often, economic benefits from farming (let alone intensification) are only a part of the diverse set of livelihood strategies and income of smallholder farmers.

There is a widely held belief in the literature and amongst the development planners that livestock has a central role to play in agricultural intensification and poverty reduction (Aune and Bationo 2008; Dercon 1998; LID 1999; J. Njuki and Sangina 2013). The benefits of animal production in smallholder systems are many and widely documented (Riethmuller 2003; Sansoucy 1995). Particularly in conjunction with crop farming, livestock (especially cattle) can provide a source of energy for cultivation and organic fertiliser allowing more intensive cultivation. Manure is often the primary input used by smallholder farmers who do not have access to or cannot afford chemical fertiliser or fallowing (Ikpe and Powell 2002; Mafongoya et al. 2007; Powell and Mohamed-Saleem 1987; Riethmuller 2003; Waithaka et al. 2007). For these reasons, integration of crop and livestock production realised through various forms of 'mixed farming', has long been encouraged and continues to be a fundamental aspect of agricultural intensification policies and strategies today (Bayu et al. 2005). Moreover, some recent empirical findings suggest that livestock, especially dairy cows and small ruminants, can be an effective, pro-poor livelihood asset helping to satisfy both household consumption needs and providing surplus production for sales (Rawlins et al. 2014; Wong et al. 2017). Other studies are more cautious, however, suggesting that the potential economic gains from intensification of small animal systems are often weak and highly variable which means that their contribution to a substantial increase in incomes of rural households is less probable (Sumberg and Lankoandé 2013; Udo et al. 2011). The next section further elaborates the concepts of livestock-based development and how different people use livestock as part of their livelihood strategies.

Livestock – the link between integrated crop-livestock and asset-based livelihood development

Livestock fulfils various livelihood functions and roles in resource-restrained families and communities. Families often purchase and rear livestock as a form of savings when the households generate surplus income. Conversely, farmers sell livestock to pay for household expenses, and to protect against financial shocks and risks during times of need and trouble. This dual 'protection-promotion' function which provides some measure of social protection against shocks and stresses while also offering livelihood and economic growth opportunities,

makes the concept of 'livestock-based asset development' an attractive and enduring element in the livelihood transformation and asset-based theory of change (Sabates-Wheeler and Devereux 2013). Based on these assumptions and prospects, various development agencies and organisations have promoted transferring of livestock assets such as cattle and small stock to economically marginalised and vulnerable families in the developing countries.

The asset functions framework

According to Dorward et al. (2001), the key to analysing and understanding the livelihood strategies of poor families is in the assets they hold, especially understanding the relative functions and attributes of these assets according to their livelihood status and plans. The authors elaborated this concept as the 'asset function framework', which is an extended model of the Sustainable Rural Livelihoods framework (Carney 1998; Scoones 1998). The authors' critique builds upon the asset categorisation broken into physical, natural, social, human, and financial. They consider the integration and the balance between the associated functions and the types of processes these assets perform such as production/income, investment, saving/cashing and borrowing. They expanded the notion of a defined set of categories (types) of assets to an operational set of attributes and components that capture the variations in asset functions. Thus, the strengths of this framework "lie in its bringing together, in a relatively simple and readily assimilated framework, a number of complex components and attributes of livelihoods" (Dorward et al. 2001: 5). Table 1 provides the example of how the eight asset attributes describe the role of livestock in the rural livelihoods.

Table 1. Attributes of some different types of livestock

Attribute	Poultry	Small ruminants (sheep and goats)	Large animals (cattle, camels)
Productivity	Depending on management, feed, etc.	Depending on sex, breed, management, feed, etc.	Depending on sex, breed, management, feed, water, etc.
Utility	Depending of preferences for eggs, poultry meat, cash, etc.	Depending of preferences for meat, wool, cash, etc.	Depending of preferences for draft power, milk, meat, hide, cash, etc.
Security	High risk of mortality esp. Newcastle disease	High risk of reduced productivity or loss associated with disease; theft in some situations	High risk of reduced productivity or loss associated with disease; theft in some situations
Holding costs	Low per unit; with low management, free roaming approach near zero	Low to high per unit depending on management (e.g., if free roaming may be near zero)	Relatively high per unit depending on breed, management and feed supply
Life	Low cost to acquire; may be held a few months to a few years; seasonal and lifecycle effects dependent on management and feeding	[intermediate]	Cost to acquire can be significant; may be held for several years; seasonal and lifecycle effects can be great dependent on management, reproduction and feeding
Convertibility	Small units, easily convertible; but of little value	Easily convertible	Large units, conversion may be difficult or undesirable; “lumpy”
Complementarity		Productivity of a female animal dependent on access to male or artificial insemination	Productivity of a female animal dependent on access to male or artificial insemination; access to appropriate equipment (plough, cart, etc.) may be needed to realise full potential
Ownership/control	Individual; few restrictions	Individual; few restrictions	Individual; may be more gendered restrictions
Social relations	Probably of little significance	[intermediate]	May be significant e.g., animals passed on from relatives; acquired through as gifts or through loan arrangements

Source: Kim and Sumberg (2015) adapted from Dorward et al. (2001)

Several points emerge from the information presented in Table 1. The effectiveness of assets fulfilling their expected roles is highly dependent on both endogenous and exogenous factors. The example of a goat, its breed and sex (endogenous aspects) as well as the differential quality of feed and management (exogenous aspects), will yield variable (*productivity*) results. Also, the motivation and aspiration of the livestock keepers (*utility*) are crucial determinants of why and how they keep goats whether for meat, hide, milk, or cash.

Dorward et al. acknowledge that there is “scope for considerable overlap” between attributes. The *life* characteristics of a goat, for instance, relates to other attributes such as *security*, *holding costs*, *convertibility*, *ownership/control*, and even *social relations*. In the latter case, if the goat is a gift or a loan, then it must not only survive but also thrive to give and pay back to the original owner the healthy offspring. Therefore, it is essential to consider in detail the “dynamic relationship between assets with different functions and various livelihood activities and processes in the pursuit of [the household’s] wellbeing” when analysing the role of livestock in the rural livelihood strategies (Dorward et al. 2001: 5).

There is one caveat with the asset functions framework. The strength of assimilation and integration is also its weak analytical point. Dorward et al. cautiously explain that “assets will differ in relative effectiveness with regard to each function” (2001: 5). As such, “[a]lthough the attributes [...] may be relatively straightforward conceptually, their objective measurement is not straightforward, due to problems with standardising units, particularly in the context of risk and uncertainty” (Dorward et al. 2001: 6). The measurement challenge is an issue when attributes are studied individually on their own. As the focus of the inquiry in this thesis is to investigate the qualitative characteristics more broadly in the crop and livestock integration context, the measurement issue can be overcome by analysing the relevant and correlational attributes holistically and contextually. Continuing with the example of the goat, a conventional way to assess *productivity* is by feed to weight gain ratio. The feed to weight gain ratio is a precise and standardised measurement best suited for agronomic and economic analysis, but here the interest lies in understanding the household’s overall livestock productivity. Therefore, the overall productivity is assessed by using other attributes such as the family’s *utility* choices for goat keeping and the risk factors arising from *security* conditions and the seasonally and (life) cyclically variable *holding costs*.

Livelihood aspiration and strategies of the poor

Dorward and colleagues’ conceptualisation of the multidimensional ‘asset functions framework’ and ‘livelihood aspirations and strategies of the poor’, succinctly explains the multiplicity of roles fulfilled by livestock in the livelihoods of the poor (2001; 2009). Dorward et

al. argue that despite the advances in expanding the conceptualisation of poverty understanding of livelihood strategies of the poor using different assets and activities has not been as widespread as might have been hoped. They emphasise recognition and understanding of the dynamic aspirations of poor people as manifested in their pursuit of a diverse set of (mix) strategies and activities. Dorward et al. identified three broad types of livelihood strategy and explained the concept of aspirations and strategies of the poor with three corresponding types of asset or activity:

- *'Hanging in'*, assets and activities are engaged in to maintain livelihood levels, often in the face of adverse socioeconomic circumstances.
- *'Stepping up'*, whereby current activities are developed, with investments in assets, to increase production and income with the aim of improving livelihoods (an example might be the accumulation of productive dairy livestock).
- *'Stepping out'*, whereby existing activities are engaged in to accumulate assets which in time can then provide a base or 'launch pad' for moving into different activities that have initial investments leading to higher and/or more stable returns. For instance, the accumulation of livestock as savings can be sold to finance children's education (investing in the next generation), or to purchase vehicles or buildings (for transport or retail activities), or to fund migration, or to acquire social and political contacts and advancement (2009: 242-3).

These three types of livelihood strategies can also be characterised in the life cycle of a family farm as proposed by Bourgeois and Sebillotte (1978). The first stage of 'hanging in' can be likened to a young couple starting out farming on their own. As the family begins to expand and the children reach physical maturity, the family consumption and production would reach new heights. At this stage, the family has to 'step up' to the challenge of meeting the rising household demands and intensify its production and expand livelihood activities. Finally, once the children gain economic independence, the network of income generation and contribution to the family farm may also grow, and further extend the livelihood activities. For instance, even if the children who pursue higher education leave family farming, they may still contribute to family farming by providing remittances. Also, even for the children who stay in agriculture, they are usually keener than their parents to branch out and try out new ways to improve the farming operations. This 'venturing' or 'stepping out' could only be afforded when the initial farming operations have reached a level of production yielding surpluses and enabling savings. Thus, as long as the primary farm production can cover the basic needs, the family (especially the young ones) can afford to try new ways to expand their production. Although this is a generalised sketch of a family farm life cycle, the analogy serves to illustrate

the changes in availability of resources for the family and the different livelihood strategies across time linked to production/income, investment, saving/cashing and borrowing.

In this chapter, technical and specialist terminology was explained. The figure on **Appendix 1** helps to clarify the dimensional order and their nested relationships. At the theoretical level, the evolutionary paradigm, developed by thinkers from Malthus through to Boserup was presented and discussed. From this theoretical legacy, the focus narrowed to three leading conceptual models for studying farm systems and crop and livestock production interactions. There was a critical assessment of McIntire et al.'s evolutionary model of crop and livestock interactions and Scoones and Wolmer's multiple pathways of crop-livestock integration. The study of smallholder farm production systems has become an important strand and subject in the literature and expands widely into various themes of enquiry. Several strands of literature, debate and policy agenda stemmed from the agricultural intensification theory and models (Table 2). The overview of this list of literature helped to narrow down the parameters of analysis for this thesis. In this research, I am particularly interested in the asset based livelihood development approach using the case of livestock to explain their role in intensification, commercialisation and other livelihood strategies for smallholder farmers.

Table 2. Key themes in the literature relating to agricultural intensification through crop-livestock integration in Africa

Themes	Sub-themes	References
Agroecology	Integrated soil fertility management	<ul style="list-style-type: none"> - Prospects for integrated soil fertility management using organic and inorganic inputs: evidence from smallholder African agricultural systems (Place et al. 2003) - Carbon and nutrient losses during manure storage under traditional and improved practices in smallholder crop-livestock systems—evidence from Kenya (Titttonell et al. 2010)
	Land and water productivity	<ul style="list-style-type: none"> - Improving water productivity in mixed crop–livestock farming systems of sub-Saharan Africa (Descheemaeker et al. 2010) - The state of the world's land and water resources for food and agriculture: Managing systems at risk (FAO 2011c)
	Soil nutrient cycles	<ul style="list-style-type: none"> - Livestock and sustainable nutrient cycling in mixed farming systems of sub-Saharan Africa – Volume II: Technical papers (Powell et al. 1995)

Agricultural productivity		<ul style="list-style-type: none"> - Nutrient allocation strategies across a simplified heterogeneous African smallholder farm (Rowe et al. 2006) - Nitrogen cycling efficiencies through resource-poor African crop–livestock systems (Rufino et al. 2006) - Network analysis of N flows and food self-sufficiency— a comparative study of crop-livestock systems of the highlands of East and southern Africa (Rufino et al. 2009)
	Bioeconomic systems	<ul style="list-style-type: none"> - Bioeconomic analysis of ruminant production systems (Fitzhugh 1978) - Beyond resource constraints – Exploring the biophysical feasibility of options for the intensification of smallholder crop-livestock systems in Vihiga district, Kenya (Tittonell et al. 2009) - Is rainfed agriculture really a pathway from poverty? (Harris and Orr 2014)
	Production intensification	<ul style="list-style-type: none"> - Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments (Byiringiro and Reardon 1996) - Agricultural intensification in the Sahel – The ladder approach (Aune and Bationo 2008) - An integrated evaluation of strategies for enhancing productivity and profitability of resource-constrained smallholder farms in Zimbabwe (Zingore et al. 2009) - Ecological intensification of agriculture — sustainable by nature (Tittonell 2014b)
	Links to markets	<ul style="list-style-type: none"> - Linking farmers to markets: different approaches to human capital development (Bingen et al. 2003) - Targeting investments to link farmers to markets: a framework for capturing the heterogeneity of smallholder farmers (Torero 2014)
Smallholder transformation	Sustainable smallholder agriculture	<ul style="list-style-type: none"> - The concept of agricultural sustainability (Schaller 1993) - Principal Challenges Confronting Smallholder Agriculture in Sub-Saharan Africa (Jayne et al. 2010) - From subsistence to profit – Transforming smallholder farms (Fan et al. 2013)
	Sustainable rural livelihoods	<ul style="list-style-type: none"> - Sustainable rural livelihoods: Practical concepts for the 21st century (Chambers and Conway 1992)

	<ul style="list-style-type: none"> - The significance of diversification for rural livelihood systems (Niehof 2004) - Livelihoods perspectives and rural development (Scoones 2009) - Livelihood strategies, resilience and transformability in African agroecosystems (Tiftonell 2014a)
Pro-poor growth	<ul style="list-style-type: none"> - A policy agenda for pro-poor agricultural growth (Dorward et al. 2004) - Pathways for sustainable development of mixed crop livestock systems: Taking a livestock and pro-poor approach (Tarawali et al. 2011)
Social protection and transformation (graduation)	<ul style="list-style-type: none"> - Can social safety nets reduce chronic poverty? (Devereux 2002) - Hanging in, stepping up and stepping out: livelihood aspirations and strategies of the poor (Dorward et al. 2009) - Sustainable Graduation from Social Protection Programmes (Sabates-Wheeler and Devereux 2013)

Source: Author's

Motivation for the proposed conceptual framework and analytical approach

In the previous sections, I reviewed the main research themes and the dominant theories that informed the arguments of the agricultural development and intensification debate in the context of sub-Saharan Africa. I also presented the two leading schools of thought that influenced the mixed farming and crop-livestock integration debate. These two approaches, advocating the evolutionary intensification paradigm and the multiple livelihood pathways, may seem at first to be at odds, but they are not necessarily so. Comparable to the story of the blind men and an elephant, both theories touch upon different dynamics of the agricultural intensification processes and describe the phenomena based on their theoretical framework and positionality, which are in turn bounded by various sets of assumptions. Instead of focusing on which line of thinking is better or 'truer' than the other, I argue that it is better to bring the different perspectives in the light of totality and to compare and learn from various research disciplines and methods to improve our understanding of crop-livestock integration in diverse contexts of smallholder production systems.

Ascertaining the various patterns of and extent of crop-livestock integration observed in different contexts of smallholders will require an interdisciplinary analysis of political, socioeconomic, and agroecological systems framed at different scales (Foran et al. 2014). Hazell and Wood (2008) identified three scales of drivers of change in agriculture, namely the

global-, country- and local-scale. An example of such an interdisciplinary approach is the French School of Comparative Agriculture (*l'agriculture comparée et développement agricole*). *Le système agraire* sees cropping and livestock production within the wider frame of farming systems. The production systems are in turn based on a broader, all-encompassing agricultural system that exists in a rapidly changing and transforming context (Barbier 1994; Blanc-Pamard and Milleville 1985; Cochet et al. 2007; Cochet 2012; Dufumier 2007). Therefore, scales of analysis need to encompass all three layers of macro- (overarching agricultural policies), meso- (interconnections between social and market forces) and micro-scale (farm-level production observation). However, while the need for more integrated and interdisciplinary analysis is well acknowledged, the vast field of analysis and the complexity involved in the interdisciplinary framework have been the base for limited empirical contributions (Foran et al. 2014; Ikerd 1993). Not surprisingly, there has been little systematic and comprehensive research to explain which agroecological systems, what crops and animals, and for whom such intensification strategies may be beneficial. Therefore, the present research study aims to fill this empirical gap by adopting an analytical framework that links the political, sectoral and family farm systems for researching agricultural intensification issues arising from crop and livestock integration. To do so, I combine the Dorward et al.'s conceptual framework of livelihood aspirations and strategies with the life cycle dimension of the farming household for the empirical analysis in this thesis (Bourgeois and Sebillotte 1978; Dorward et al. 2009).

One way to study the often complex nature of livelihood strategies and asset holding is through the combining quantitative with qualitative data analysis as a 'mixed methods' approach. This is defined as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (Johnson and Onwuegbuzie 2004: 17). For instance, by moving the analysis from the particular smallholding household to the village level, it becomes possible to incorporate analysis of the agricultural markets and public programmes that are significantly influenced by the policy agenda. To build this analytical framework, it was necessary to collect "multiple data using different strategies, approaches, and methods in such a way that the resulting mixture or combination is likely to result in complementary strengths and non-overlapping weaknesses" (Johnson and Onwuegbuzie 2004: 18). In the next section, I explain how I adopted the mixed methods research design for this study.

Chapter 3 – Methodology

Research design

This research was based on the exploratory sequential design (Creswell and Plano Clark 2011: 71). The exploratory sequential design unfolds in multiple, iterative phases where initial exploratory qualitative data feeds back to the primary research instrument – in this case, a household survey.

Collection and analysis of quantitative data

are then followed up by qualitative inquiries such as life-story interviews, but this time with a focus on the specific observations made in previous phases which warrant more in-depth analysis (Figure 4).

Several research instruments were used to collect the appropriate data to answer the research questions (Table 3). The research questions were addressed from three vantage points: policy, sectoral, and farm household level. Scale sensitive analysis is necessary in this study because the agricultural policy agenda usually takes shape and place in the one dimension of the policy sphere and it is then implemented elsewhere such as at the market and farm-level. This relational dimension (or frontier) is a crucial juncture where it is possible to find out if the policy-making sphere is or is not connected and grounded in rural reality. However, the dynamics of decision making and how policy processes work do not form the focus for this study. Instead, the first phase of the research inquiry focuses on the why and what of the agriculture policy and how the policy sphere interrelates with the agriculture sector through private sector market value chains and public programmes (related to the sub-questions 1.1, 1.2, and 1.3 in Table 3). This is done by addressing the sub-questions linked to three broad field of research. In the next section, each sequential phase of the research design is elaborated upon in detail.

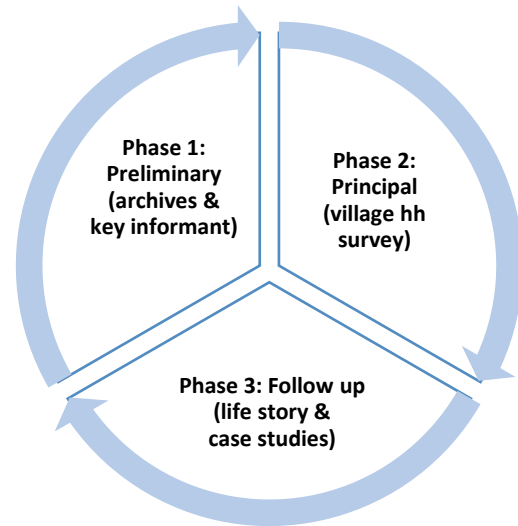


Figure 4. Exploratory sequential design

Table 3. A summary of the research sub-questions, data types and research instruments

Sub-questions	Research field	Data	Methods & Instruments
<p>1.1 How has agriculture policy developed and changed in Rwanda?</p> <p>1.2 What roles have been envisaged for crop-livestock integration?</p> <p>1.3 How have framing and narrative been used to support these policy positions?</p>	Policy analysis	<p><u>Qualitative</u></p> <p>Historical accounts and data from official publications & archives</p>	<p>» Archival search at the <i>Agricultural Information and Communication Centre</i> (CICA) in Kigali and <i>British Library for Development Studies</i> (BLDS) at the University of Sussex, UK: text data analysed with <i>NVivo 10 for Windows</i>;¹³</p>
<p>2.1 What is the evidence base supporting intensification through mixed crop-livestock farming as a viable livelihood option for the smallholders in Rwanda (i.e. in relation to productivity, environmental sustainability and social acceptability)?</p> <p>2.2 What are the patterns of crop-livestock interactions and their engagements with economic and subsistence-based livelihood activities?</p> <p>2.3 What are the patterns of crop-livestock interactions, management, activities and amendments and their engagements with soil fertility?</p>	Social history; Agro-ecology; Socioeconomic	<p><u>Qualitative</u></p> <p>Farmers' perspectives & experts' opinions</p> <p><u>Quantitative</u></p> <p>Empirical review; Household food security; mixed production systems; market assessment</p>	<p>» Participatory methods such as transect walk – generating field notes, village mapping and visual materials such as photography and short-video clips;</p> <p>» Field observations and semi-structured interviews with farmers and district-level extension agents;</p> <p>» Secondary research: using online database such as <i>SCOPUS</i>, <i>Web of Knowledge</i>, etc.</p> <p>» Household survey questionnaire: Livelihoods Analysis Framework (Ellis 2000) and gender-disaggregated data and conceptual framework on livestock as a pathway out of poverty (Kristjanson et al. 2010), integrated modelling platform for mixed animal-crop systems (IMPACT) (Zingore et al. 2009), Locational characterisation for developing countries' context (Wiggins and Proctor 2001), will be analysed with <i>Stata 13</i>¹⁴</p>
<p>3.1 What does the experience of promoting crop-livestock integration tell us about asset transfer programmes and asset-based development strategies in Rwanda?</p> <p>3.2 For whom, and in what circumstances is livestock keeping a successful livelihood promotion and a potential pathway out of poverty?</p>	Socioeconomic	<p><u>Qualitative</u></p> <p>Diversity in rural livelihoods; Life stories</p> <p><u>Quantitative</u></p> <p>Asset portfolio; market assessment</p>	<p>» Life story interviews with farmers and key informants: generating notes, life cycle diagrams for analysis (<i>NVivo 10</i>)</p> <p>» Household survey questionnaire: Asset-based index & principal component analysis (Filmer and Pritchett 2001) (<i>Stata 13</i>)</p> <p>» Local market visits, open-ended interviews with vendors: generating field notes for understanding the market and commercialisation for smallholder farmers</p>

¹³ *NVivo 10 for Windows* – http://www.qsrinternational.com/products_nvivo.aspx

¹⁴ *Stata 13*: data analysis and statistical software - <http://www.stata.com/stata13/>

Phase 1: Archives

The main subject of inquiry and analysis of the first set of research sub-questions (1.1, 1.2, and 1.3 in Table 3) is concerned with policies. Generally speaking, a policy is about setting a course of action to accomplish a goal that is of public interest. We seek to establish how, why, when, and who dictates and sets such a course of action. This draws us into the political field. Calvert has presented politics as “the making of decisions in society,” adding that “politics is not action, though, but interaction; it is both what decision-makers do to people, and what people do to try to influence the decision-makers” (Calvert 2002: 4). Thus, to study a policy agenda and the politics lying behind it, benefit is gained by firstly understanding the underpinning historical and social dynamics that instigated, influenced, and mobilised the processes and interactions involved in thinking, designing and implementing such an agenda (Calvert 2002: Ch.1). One of the ways to study policies is comparative public policy analysis (Calvert 2002; Harrop 1992; Parsons 1995). There are three main approaches towards comparative analysis: across countries, within a country, and across policy sectors such as industrial policy or health policy (Harrop 1992: Ch.1).

In the present case, the comparison and analysis is between the Rwandan agricultural development agenda set forth by the pre- and post-1994 governments. The archives used for the analysis are from the Agricultural Information and Communication Centre (CICA) in Kigali, Rwanda and the British Library for Development Studies (BLDS) at the University of Sussex, UK. The search period covered all documents since the independence of Rwanda in 1962 to the beginning of the literature review in 2013. The main body of material used for analysis came from government texts (for policy analysis) and some non-governmental reports (for more in-depth contextual analysis of how policies have changed across the period). The files consisted of 50 French documents dating back from 1969 to 1999 (see **Appendix 2**),¹⁵ and 15 English documents from 1998 to 2013.¹⁶ The types of archives consisted of government reports such as agriculture surveys, national policy papers, and sectoral strategy papers. Other materials

¹⁵ The author translated all of the French citations used in this thesis. See **Appendix 3** for the original excerpts for reference.

¹⁶ The intersection of time (1998-99) and the change of official language of archives mark a turning point for leadership within the post-1994 government. The official reason for changing the administrative and business language of the country from French to English has to do with joining a wider global market community. But the other (more pragmatic) reason is that the majority of the incumbent ruling political party, the Rwandan Patriotic Front (RPF) leadership members are the second-generation Tutsi diaspora from Uganda, where English is the lingua franca. Secondly, the diplomatic relations between the French government and the previous ruling party, *Mouvement Révolutionnaire National pour le Développement* (MRND) was strongly criticised by RPF, and hence it was another reason to cut the diplomatic and cultural ties with the French.

consisted of agriculture bulletins, official speeches, and donor agency reports. I used *NVivo* (version 10.2.2), a qualitative data analysis software, to design, manage and analyse the archive database. French archives were transcribed onto *Microsoft Word* document first and then imported to the *NVivo* database. I imported the English files directly to the database as most of them were available online and in Portable Document Format (PDF).

Phase 2: Village studies

Choice of fieldwork sites and rationale

It is argued that the primary objective of agricultural intensification policies is to meet the country's economic and food security objectives (GoR 2004b). Therefore, to analyse the ramification of agricultural intensification policies, I need to carefully look at the relationships between agricultural productivity and household food security and asset-based livelihood development. Similarly, to assess the crop-livestock interactions and to understand their role in intensification and commercialisation processes, the areas of study must be geographically situated in an area where the forces of commercialisation and specialisation of production systems are active and present. The presence of dairy markets (both formal Milk Collection Centres [MCCs] and informal value chains) and agro-food transformation industry (essential for industrial animal feed) are relevant for investigating the forces of commercialisation and specialisation. The district of Rwamagana in the Eastern Province satisfied the above conditions (Map 1, p.56). Rwamagana district (an hour by car from Kigali) is one of the rapidly urbanising regions with a strong potential for agri-business development and with easy access to markets in Kigali. Rwamagana district has five milk collection centres. Most of the MCCs sell their milk to Inyange, the country's largest dairy processor (about forty minutes by car from Rwamagana). Rwamagana is also located in the 'maize corridor' where Minimex Ltd., one of the largest buyers of local corn and the biggest producer of processed maize products in Rwanda. The company operates its milling plants at Kayonza, the neighbouring district east of Rwamagana, and in the outskirts of Kigali which is less than an hour's journey by car from Rwamagana. The district of Rwamagana is composed of 14 sectors, 82 cells, and 474 villages (*imidugudu*) and it has a population of 310,238 with an average annual population growth rate of 3.5 per cent. According to the census data from 2002 to 2012, the population density in Rwamagana was 455 people per square kilometre (with a surface area 691.6 square kilometres) (GoR 2013e). Key features of the district and the national figures are presented in Table 4.

Site selection

Two sites are of interest in the district of Rwamagana: a village in the *peri-urban zone* and a *rural village*. The purposive selection of the study aimed to highlight the differences in the social, agricultural, and market conditions that exist between the peri-urban and rural villages. So that in return, the areas with different agricultural and socioeconomic comparative advantages will help explain the various roles of crop-livestock interactions in the intensification and commercialisation processes.

The district agronomist and veterinarian were instrumental in accessing the official district documents, planning maps, and the contact information of the village leaders. Moreover, they provided and explained the institutional perspectives on agricultural and livestock development objectives set out by the central government (i.e. Rwanda Agriculture Board and Ministry of Agriculture and Livestock Resources).

Table 4. A summary of key development indicators for Rwamagana district

	Rwamagana	National
Population size	318,000	10,800,000
<i>proportion of households headed by females</i>	33%	28%
Poverty count ¹		
<i>poor</i>	30%	69%
<i>non-poor</i>	70%	31%
Having access to/and using		
<i>an improved drinking water source</i> ²	82%	74%
<i>an improved sanitation facility</i> ³	62%	74%
<i>at least one saving account in a household</i>	49%	39%
Proportion of people employed in ⁴		
<i>agriculture</i>	76%	
<i>trade</i>	8%	
Proportion of people working as ⁵		
<i>an independent farmer</i>	68%	85%
<i>a wage non-farmer</i>	13%	28%
<i>an independent non-farm worker</i>	10%	25%
<i>a wage farm worker</i>	6%	35%
The mean size of land cultivated per household (Ha)	0.70	
<i>proportion of land protected under erosion</i>	89%	84%
Proportion of households		
<i>cultivating <0.3 Ha</i>	42%	
<i>purchasing chemical fertiliser</i>	31%	29%
<i>commercialising crop production</i>	24%	21%
<i>raising some type of livestock</i>	70%	68%

¹ The extreme poverty line corresponds to RWF 83,000 (approx. USD 105) and the poverty threshold to RWF 118,000 (USD 150), using the exchange rate of USD 1: RWF 785.

² An improved drinking water source includes protected springs, public standpipes, water piped into the dwelling, boreholes, protected wells, and rain water collection - as defined by the World Health Organisation (WHO).

³ An improved sanitation facility means flush toilets and pit latrines with a floor slab.

⁴ In Rwanda, 16 years is the legal working age. The overall employment rate was 84 per cent of the resident population aged 16 years and above.

⁵ Although the majority of adults work on their family farm for some of the time during the year, many do more than one job. Therefore, the cumulative proportion exceeds 100 per cent.

Source: The Third Integrated Household Living Conditions Survey (EICV 3) by National Institute of Statistics of Rwanda (GoR, 2013e).

For the preliminary assessment of the field sites, I consulted with the staff of the Kigabiro Milk Collection Centre (MCC) also registered and known as the *Dairy Cooperative Dukundamatunga* (here on Kigabiro–MCC). The Kigabiro-MCC members make up an ideal sample of crop and dairy farmers. The members' scale of operations ranged from one-cow (zero-grazing) production to large-scale pasturing systems. Semi-structured interviews and farm visits helped contextualise the day-to-day crop and dairy operations. Also, farmers' life stories and livestock-keeping history broadened the scope of meaning and value of livestock as a livelihood asset.

Amongst the five milk collection centres in Rwamagana that are located in the Gahengeri, Kigabiro, Rubona, Gishari and Muhazi sectors (Map 2, p.57), MCC in Kigabiro was the most significant regarding the membership size and the amount of milk collected daily. The list of active milk suppliers – consisting of 44 per cent cooperative members and 56 per cent non-members – of the Kigabiro-MCC was used to assess the range of dairy providers and their geographical locations in Rwamagana (Table 5).

Table 5. Total volume of milk collected from the Kigabiro-MCC members and non-members

Sectors	Non-members	Volume (Litre)	Members	Volume (Litre)	Total (Litre)
Muhazi	35	25,062	25	11,419	36,481
Kigabiro	18	2,895	25	12,052	14,947
Mwulire	14	5,271	14	11,158	16,429
Gishali	18	4,144	10	4,841	8,985
Munyaga	5	503	1	61	563
Munyiginya	3	18,391	0	0	18,391
Musha	1	312	1	396	708
Kayonza District	1	675	1	870	1,545
Rubona	1	5,477	0	0	5,477
Aggregation point	1	911	0	0	911
TOTAL	97	63,641	77	40,796	104,437

Source: Accounting records of Kigabiro-MCC from October 2014 to March 2015

The top three milk producing sectors are Muhazi, Kigabiro and Mwulire (Map 2, p.57).

Although the Munyiginya and Rubona sectors are, regarding milk volume, the second and sixth largest contributors (18,391 and 5,477 Litres, respectively), they are considered 'outliers' in this study. Notice the number of suppliers in Rubona and Munyiginya sectors: there are only

one and three suppliers from the areas, respectively. They are in fact what the cooperative manager described as ‘aggregation-point-collector’: an individual collector gathers all the milk in the vicinity as a single buyer and sells it back to the cooperative. What is interesting is that these ‘aggregation-point-collectors’ were not yet members of the co-op. The reason why the big suppliers are refraining from joining the cooperative has to do with the rules of the membership and costs. Due to the limited time and scope, I did not follow up with these outlier cases. The business acumen and entrepreneurship strategies of these large-scale milk collectors are fascinating and more research are warranted.

Sixteen Kigabiro-MCC members from the three highest milk supplying sectors were visited and interviewed as part of the exploratory inquiry. This included five cooperative members from Muhazi; four from Kigabiro; and seven from Mwulire. The selection method of interviewees was as follow. At the Annual General Meeting (AGM) of the cooperative held on March 10, 2015, I introduced the research rationale and objective and asked the cooperative members for participation. From a pool of over 60 members present at the AGM, I shortlisted the members from the top three milk supplying sectors and contacted them the day after the meeting to arrange a visit and interview. Nearly all the members contacted responded positively to the call. Subsequently, household and farm visits in the Muhazi, Kigabiro and Mwulire sectors informed the selection of two villages for the second phase of the fieldwork. Accordingly, I purposively selected two sites in the district of Rwamagana, a village in the peri-urban zone and a rural community (Box 1).

Box 1. Understanding the village settings

A case of a peri-urban village (proximity to market and with good public infrastructure) – Umuganura village is about 20 to 30 minutes away (by walking) from the main market centre in Rwamagana. Most of the houses are 5 to 20 minutes away (by walking) from the main road. The village counted 163 permanent households and amongst them, were several successful agri-business entrepreneurs, which included specialised egg production, commercial pig production, an industrial maize mill and animal feed production plant. The quality of soil fertility in this area is relatively weak and requires manure. There is no organised cooperative operating in this village.

A case of a rural village with good resources (strong leadership and group solidarity) – Gisanza village is five kilometres away from the main road. People usually walk to the main road which takes about an hour, then take local transportation to go to the market in Rwamagana (about 15 minutes by motorcycle or bus). Cycling to town is difficult as the road to Rwamagana is hilly and most of the way is unpaved. Over 30 households are participating in the *Girinka* programme, which is a national asset transfer programme that subsidises and gives dairy cows to eligible rural households. There is a village-level cooperative that collectively promotes milk, banana and maize production and marketing. In 2011, the cooperative successfully bid for the access to grow corn in the valley marshland (24 hectares) as part of the Land Use Consolidation programme. Forty-two households were participating in this scheme at the time of the fieldwork.

Village census, mapping and household survey

The household was considered appropriate as the social unit of analysis for this study (Ellis 2000). There were no complete lists of houses or village maps available at the district office. With the permission of the head of the villages, a detailed walking map of the village and door-to-door census were carried out (Map 3 and 4; p.58 and 59). The total population in Umuganura consisted of 170 households and in Gisanza 136 ($N_1=170$; $N_2=136$). The census data gathered a number of essential facts about the family such as the household size and family composition, the head of the family's primary income generating activities and if they were farming, access to land and livestock ownership. Taking into account of all the vacant houses and absentees as well as households that did not farm, a sub-sample of all farming households in Umuganura was selected consisting of 135 families and then 132 families in Gisanza.

Based on field observations of the livestock ownership characteristics, the sample was further disaggregated and stratified by the household's animal ownership: i.e. without livestock, with small stock only, with cattle only, and with cattle and small stock. The logic of the stratification was to identify the different subgroups according to their crop-livestock integration capacity and to ascertain their relative group sizes. From this pool, I drew a stratified random sample of 169 households ($n_{TOT}=169$): that is, 89 farming households from Umuganura and 80 from Gisanza village ($n_1=89$; $n_2=80$). Stratified sampling ensured a representative selection and coverage of each livestock holding type (including those with none).

The goal of the survey was to assess the diverse rural household characteristics such as family composition, means of livelihood and occupations, and asset ownership and access to various resources and services (see the survey questionnaire in **Appendix 4**). The household surveys were carried out with the help of four local research assistants (two males and two females) (Picture 1). They were recent graduates from the Institute of Agriculture, Technology and Education



Picture 1. Local research assistants

in Kibungo and two of them had degrees in agriculture and rural development, and the other two had degrees in education and economics. Three of the research assistants had extensive fieldwork and quantitative data collection experiences. Prior to fieldwork, all of the research assistants were closely involved in the process of questionnaire development, translation

(from English to Kinyarwanda and back) and survey methods training. The first two weeks of data collection with the Kigabiro-MCC members served as training and quality control purposes. Also, a locally adapted and translated informed consent form was explained to all study participants prior to the survey and interviews. All 169 households gave free and voluntary (and signed) agreements to participate in the study.

To ensure the quality and accuracy of the data, establishing trust with the respondents was crucial. The frequent and iterative data collection processes helped in gradually building rapport with the villagers. First, village mapping and door-to-door visits took several days to complete, and allowed the villagers to ask why and what we were doing in their village. Some of the information such as the number of livestock ownership and land size could have been inaccurately reported (Jemimah Njuki et al. 2011). To circumvent this problem, research assistants and I insisted on sitting outdoors in the backyard, where we could easily observe the number of animals kept in the shed. Also, when the reported land size was questionable, we either asked to inspect the plots visually or to verify the exact size indicated on the official land certificate.

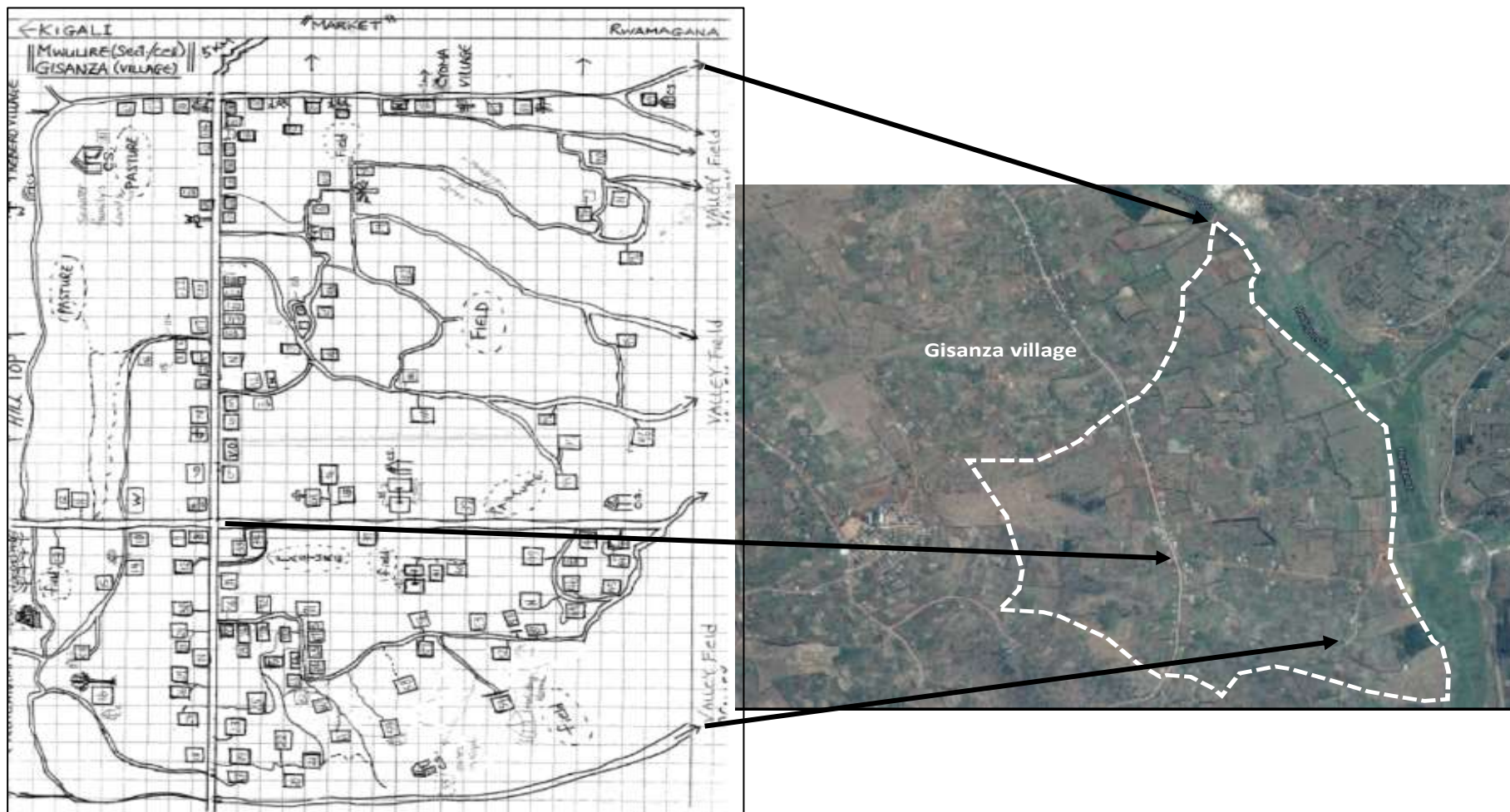
Some of the information gathered in this study is sensitive and personal, especially life events during and in the aftermath of the genocide, and all the research assistants and I adhered to strict measures of confidentiality and anonymity. All research design and instruments including the survey questionnaire were reviewed and approved by the ethical boards from the University of Sussex and the Ministry of Education in Rwanda (see **Appendix 5**).



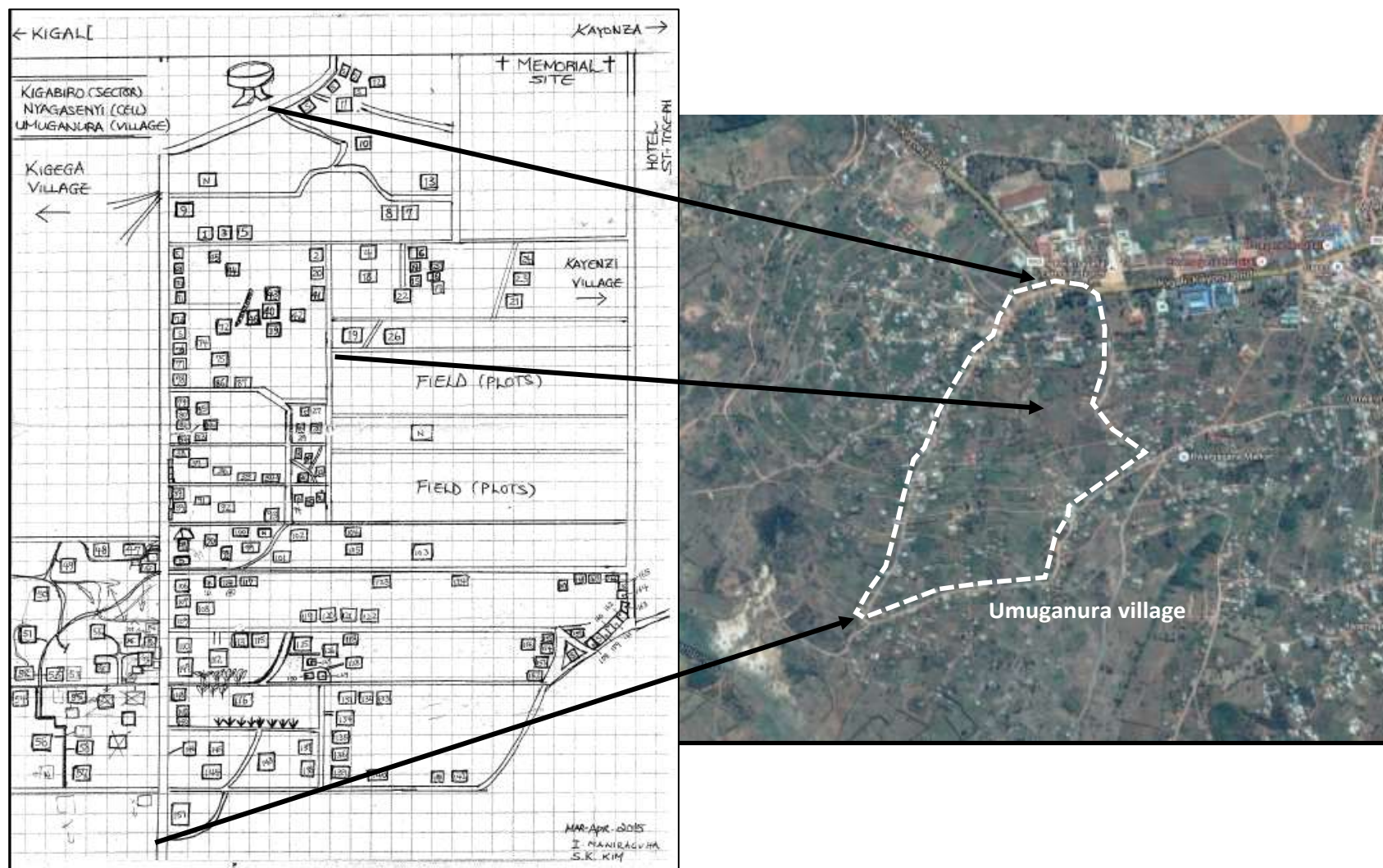
Map 2. Administrative district of Rwamagana

Note: Neighbouring district names are in bold; otherwise, they are names of the sectors of Rwamagana.

Source: GoR (2013e)



Map 3. Author's village map of Gisanza (2015) shown with the Google satellite image



Map 4. Author's village map of Umuganura (2015) shown with the Google satellite image

Phase 3: Life story analysis

The preliminary assessment of the surveyed households showed various ways in which families keep livestock. Although, a general typology is informative, what is more important, however, is to understand what the story behind every crop-livestock typology is. What are the different life circumstances and events that caused or led to diverse standings of current asset endowment and the adoption of particular livestock-based livelihood strategies? What are the possible causal mechanisms that can help explain the types of crop-livestock integration observed and the dynamics of assets and wealth accumulation? In an attempt to uncover the patterns and possible causal factors, “[t]here may be no better way to answer the question of how people get from where they began to where they are now in life than through their life stories” (Atkinson 1998: 20). The life story as a narrative form “is a qualitative research method for gathering information on the subjective essence of one person’s entire life” that aims to make “the implicit explicit, the hidden seen, the unformed formed, and the confusing clear” (Atkinson 1998: 3 & 7).

Using a list of the essential guiding questions (Atkinson 1998)(see **Appendix 6**), I conducted the life story interviews with the help of two research assistants (as scribe and translator). Initially, during the training and piloting phase, I audio-recorded the interviews, but the difficulty of gaining the consent to record personal and sensitive life stories of some participants made this option impractical. Instead, I transcribed the interview in live coverage in two languages, Kinyarwanda (transcribed directly by one assistant) and English (interpreted by the other assistant and transcribed by me). I asked my assistants to alternate their roles to understand the ins and outs of scribing and interpreting interviews, which significantly and quickly improved the quality of data collection. At the end of each meeting, I cross-checked both copies of the transcription to find and clarify any missing gaps.¹⁷

I conducted the life story interviews in Umuganura ($n_1=14$) and Gisanza ($n_2=16$) villages and with the Kigabiro-MCC co-operative members ($n_3=16$) in Mwulire, Kigabiro and Muhazi sectors (Table 6). A total of 47 in-depth interviews with the farmers owning different types of livestock helped to tease out the different meanings, values and associated costs (risks and liabilities) of livestock keeping, particularly in their relation to the farming practices and livelihood strategies of households. On the other hand, I was equally interested to hear from the villagers who had no livestock. I probed these farmers’ views on why they could not rear any animals

¹⁷ The original transcripts are handwritten, and some are scarcely legible. The transcribed interview notes are available upon request.

through a series of semi-structured and open-ended questions administered during the household surveys conducted in Umuganura and Gisanza villages. The data from the farmers without livestock (42 cases) revealed the significant constraints that bar the livestock production and accumulation process from taking place. Amongst the interviewed farmers, some stories stand out as successful examples of commercial farming and agri-business enterprises as cases of specialisation and capitalisation on economies of scale.

Table 6. List of interviewed farmers for the life story analysis in Rwamagana district

<i>Farmers who own</i>	Umuganura	Gisanza	Kigabiro-MCC	Total
no livestock*	21	21		42
small stock	6	1		7
cattle	3		16 ^Δ	19
cattle and small stock	7	14		21
<i>Total</i>	37	36	16	89

* I solicited the opinions and perspectives of the farmers without livestock through semi-structured and open-ended questions during the household survey. All other cases were in-depth interviews (explained in detail in chapter 7).

^Δ One cooperative member had a farm in Gisanza but lived elsewhere. Therefore, his household was not included in the survey sampling (not shown in Gisanza column) but was part of the life history interview group. Explained more in chapter 7.

The life circumstances of the story tellers are unique in the personal sense, but they are also grounded in common historical events and society-wide changes, in which I can study livestock for its social and cultural values and functions. Moreover, a gendered perspective on animal asset ownership and related management activities is important to highlight the different costs associated with the responsibilities and liabilities that exist between male and female farmers. I analyse the life story data in two parts. Firstly, I review each life trajectory of the farmers and their livestock accumulation pathways. Next, I examine all the stories in the context of ‘beginning, middle, and resolution’ pattern. This timeless and universal plot, often found in traditional stories, “has many versions and can be represented as birth, death, rebirth, separation, initiation, [and] return” (Atkinson 1998: 2). I use this template to discern the shared and general experiences drawn from the diverse life opportunities and crises that shape and influence the livelihoods and crop-livestock integration pathways.

In the second part, I analyse the main enabling and constraining factors for livestock development identified in the first part and relate them to the government policies and the NGOs intervention programmes that promote livestock asset-based development.

Additionally, I use the key informant interview data with the country-level managers of the livestock-transfer programmes administered by the Ministry of Agriculture and Livestock Resources and the international NGOs (Heifer International and the Send a Cow Rwanda) based in Kigali to corroborate the farmers' experiences and accounts of livestock development programmes.

Integrating the analyses of the findings

Beyond the sequential construct of the research design, I also seek to find the complementarity of the mixed method in the integration of data analysis and interpretation of the findings. To be sure, integration of results does not always yield clarity, convergence, and corroboration of results from the different methods used. Similarly, the findings may not necessarily agree with one another. However, such contradiction is equally useful in 'discovering paradoxes' and in reconsidering the researcher's initial assumptions and expectations, and if necessary, reframing of the questions (Johnson and Onwuegbuzie 2004: 22).

In this thesis, I integrate and synthesise the empirical findings of the three subsets of research queries (see Table 4). The first part of the questions (1.1 – 1.3) sets the scene for the overarching argument and the research context of this thesis: that is, tracing the elements of continuity and change in the crop and livestock integration narrative evolving through the historical and political development of the agricultural intensification policies in Rwanda. The policy analysis presented in chapter 5 does not directly relate to other empirical findings at first. However, I discuss the policy analysis and its implications along with the rest of the findings from the village study and life story interviews later in chapter 8.

The next two sets of questions are more related to each other than with the first. The second round of questions (2.1, 2.2 and 2.3) is concerned with the description and cross-sectional observations of the household production and livelihood activities. The key empirical findings presented in chapter 6 are the characterisation, categorisation and typology of various livestock holding and the assessment of the benefits and costs associated with their respective asset attributes.

These findings prompt the next set of questions (3.1 and 3.2) and try to deepen the understanding of the underlying (causal) dynamics of crop-livestock integration pathway in the rural and peri-urban settings in Rwanda. This following up allows me to bring in the temporal dimension of asset-based development, retrospectively, to the cross-sectional household

survey data. The ultimate objective of integrating the quantitative and qualitative analyses is to expand and deepen the analytical scope. By complementing the detailed descriptive findings captured in the household survey data with the highly contextualised life story interviews, we can enrich our understanding of the many pathways of livelihood development and their various derivatives of aspirations and strategies and intentions and happenstances of the smallholder farmers more meaningfully.

A critical reflection on the mixed method approach

The choice of research methods is never entirely objective (i.e. for the sake of research only). Rather, it depends on the set of beliefs, values, and assumptions of the research community that one belongs to (Johnson and Onwuegbuzie 2004: 24) and the technical training and capability of the researcher (Morgan 1998: 371). So far, I have presented the merits of complementarity and a pragmatic approach to the mixed method research. However, to avoid reiterating only the positive aspects, I want to clarify my positionality and offer my reflection on the methodological choice being made in this study.

At the time when I was applying for the doctoral position at the Institute of Development Studies, I was already aware of the institute's long tradition in mixed method and participatory research work. I believe that my disposition towards interdisciplinary research is a direct result of my academic training and background which spans from environmental geography to business management and sustainable development to food and resource economics. In other words, without my previous experiences and exposures to the different natural and social science disciplines and the strengths and weaknesses of each paradigm, I would not have the same conviction and interest in the mixed method approach today. However, although I believe that the sequential mixed design is well suited for the research questions that I investigate in this thesis, this does not necessarily mean that the quantitative or qualitative method on their own is incomplete, inadequate or methodologically inferior to the combined method. Rather, these methods achieve different outcomes and can be used to inform different types of disciplinary enquiries. A panel data collection of household surveys, for example, could have also captured the time dimension that the life story interview provides. Since I could not afford a long-term fieldwork study, and considering the limited resources I had for this research, I had to find an affordable and timely way to gather from as broad and meaningful as possible sources of knowledge and information. Therefore, the combination of the selective surveys of the rural and peri-urban settings and the collection of rich life stories of crop-livestock farmers that are rooted in a historical development perspective of agriculture

intensification policies in Rwanda emerged as the most suitable and feasible research methods of choice.

Before I move on to the empirical findings, let me start by introducing the agricultural development context of Rwanda, which will help establish the chain of reasoning that brings all the elements of theories, concepts and methodological justifications presented for this research. In the next chapter, I provide a summary of the agroecological, historical, and political background of Rwandan agriculture that are necessary for understanding the research context of this thesis.

Chapter 4 – Rwanda: national context

A brief historical review: the land, the people and livestock

Rwanda is at the heart of central and eastern Africa (geographical coordinates: 2°00'S 30°00'E). It has a high average altitude of above 1,000 metres above sea level and a tropical climate with, on average, between 900 to 1,600 millimetres of rain annually spread over two rainy seasons (bimodal precipitation distribution). Rwanda is a relatively small and rural country (26,338 square kilometres) in the region with over 70 per cent of the population living in the countryside (World Bank 2017). The majority of people inhabit the hillsides where agro-climate conditions are conducive to farming but also where high altitude and cooler temperature (24 to 27°C on average) are natural deterrents to tropical diseases. Rwanda has four seasons, which allows for two rounds of cropping and harvest.¹⁸ These favourable conditions made Rwanda's hillsides a prime location for settlement, crop farming and livestock rearing.

There are three ethnic groups – the Twa, the Hutu and the Tutsi – who have settled in the Rwanda-Burundi region. Historical evidence on the arrival and migration patterns of these groups are speculative (Mamdani 2014: Ch.2), but the most popular accounts place the hunting and gathering Twa people as the first settlers. Then, Hutu farmers came sometime between the 5th and 11th centuries, and finally, the Tutsi pastoralists settled around the 14th century (Twagilimana 2007). The rich agroecological environment and the tropical climate provided varied means of livelihood and modes of production. The Twa were hunters and gatherers, and their habitat and livelihoods mainly derived from forests. Therefore, their environmental impact and demographic growth closely followed the natural cycles of production and reproduction. The Hutu were land cultivators who depended on cleared land and fertile soil for crop production. They used simple farming tools, practised land clearing methods (slash and burn and shifting agriculture), and relied exclusively on the manual labour force. Therefore, their production levels were limited to the amount of physical workforce available for territorial expansion. The Tutsi were cattle pastoralists, and their means of production required access to extensive tracts of land for grazing and fresh water. Having a permanent access to grazing land and water would have caused tension with other early settlers who also relied on the same natural resources for survival. The established power

¹⁸ The first short rainy season starts from mid-September to mid-December (*Umuhindo*). Then, a brief dry period from end of December to early February (*Urugaliyi*) follows. A longer rainy season from mid-February to early June (*Itumba/Urushyana*) sets in, and finally, a long dry season from June to early September (*Icyi/Impeshyi*) completes the farm production cycle (Mfizi 1983).

structure of the expansionist (the Tutsi warlords) and the conquered Hutu and Twa people, created a host of social, political, and cultural dynamics and obligations between the Tutsi and the other ethnic groups.¹⁹

There were two major economic activities in pre-colonial Rwanda: cattle rearing and crop farming. Cattle production was regarded as being superior to crop production and livestock had a significant sociopolitical and cultural value that allowed its owners to exercise political power and influence over those who either were without or owned fewer cattle. The common answer to why cows became a centrepiece of political and cultural currency lies in the social order and power structure surrounding cattle ownership and labour mobilisation. There were several aspects of the social relations and political dynamics that existed between the Hutu and the Tutsi in the pre-colonial era. Initially, both the Hutu and the Tutsi were organised in patrilineal affiliations, in family clans. At the top of the ruling class and command were the royalty, who were represented more broadly and locally by the regional warlords and chiefs. In the sixteenth century, a Tutsi king named *Ruganzu II Ndori* established a central monarchy that unified all of the small independent kingdoms of central Rwanda and outlying Hutu kingdoms (Twagilimana 2007).

During this time, cattle became the ultimate social, political and cultural symbol of wealth in Rwanda. The lifestyle and livelihood activities associated with cattle raising and crop farming were markedly different. The former relied on a smaller number of labourers (herders), and the work for the owner was minimal regarding time and labour. Whereas for crop cultivation, the increase in crop yields directly depended on the increase in physical effort and time spent on farming. Livestock production was also considered more resilient to weather risks. For instance, while crop production was bounded by its geographical location and was contingent upon rainfall and weather, cattle owners could move to another pasture or water source if the local conditions were unfavourable. Droughts were frequent despite Rwanda's bimodal rainfall which permits two rounds of alternate cropping for most crops if the production cycles were well managed. The economies of scale of pastoral production relying upon only a handful of herders made it more able to take care of a much large number of cows. Consequently, it becomes possible to provide a reliable and constant output of milk and meat throughout the year (Rwasamilera 2015).

¹⁹ The Twa are mostly absent from political involvement in Rwanda. Representing only about one percent of the population, they suffer from denigrating views characterising them as being primitive and second-class people by the Hutu and Tutsi groups. For more detail, see Lewis (2006).

More importantly, politically, the advantages of cattle rearing over farming were structurally exploited. An elaborate cattle-based labour contract or clientelism called *Ubugake*, a client (*umugaragu*) and patron (*shebuja*) contract between a Hutu and a Tutsi chief around cattle became the prominent symbol of Tutsi domination over the Hutu (Twagilimana 2007). The *ubuhake* system served two socio-economic functions. Firstly, in the absence of a monetary economy and with exclusive cattle holding by the Tutsi, the only way for a Hutu peasant to own a cow was through a labour contract – as a vassal – with a Tutsi chief. Secondly, similar to other feudalistic arrangements, people (even those with cows) sought military protection from the dominant Tutsi leaders and the Monarch. Those who had large herds of cattle also had a well-trained group of armed men to protect (or inversely, suppress) them (pers. comm. Rwasamilera 2015). While the *Ubugake* contracts are now a thing of the past, as I will explain more in detail in chapter 7, the role of cattle in the farming context and their social and political value still command a certain prestige and importance until today.

Food and agriculture development

In chapter 2, the issue of increasing population and pressure on land for growing food was discussed in relation to how it led some to believe that the Rwandan economy and demography were caught in the so-called ‘Malthusian trap’. According to this logic, if left on its own, such a society will be at risk from irreversible natural resource degradation and social (and political) unrest. It is easy to dismiss the Malthusian argument with the simple fact that today, more people are living in Rwanda than ever before and that there is no imminent threat of famine or massive food shortages. What is harder to disapprove, however, is the ongoing premise of the Neo-Malthusian argument which argues that the issues of decreasing arable land size per household and poor crop productivity will eventually lead to disaster. Against these apparent contradictions, the case is made here for a more rigorous interdisciplinary analysis of the agricultural development experiences in Rwanda and the study investigates the role of crop-livestock integration in achieving small-scale agricultural intensification. However, in the following sections, there is a brief outline of how the agriculture agenda developed over the years, situated in the current government’s vision of agriculture within this historical perspective.

Throughout its colonial and post-colonial history, food self-sufficiency and commercial production interests dominated the country’s development plans. Unsurprisingly, with over 90 per cent of the population relying on farming when Independence occurred in 1962, the social and political expectations were high for the government to develop and intensify agriculture.

With population growth outpacing farm productivity, however, Rwandan farmers needed more land for food production. This demand resulted in the opening and expanding into sub-optimal farming areas such as the swamps, steep hillside, and forests (Figure 5). The increase in food production through land expansion, however, did not keep up with the population growth rate. Despite more land being made available for farming, the absolute size of arable land per person decreased over time (Figure 6).²⁰

Thus, food security and agriculture productivity became the biggest preoccupation for the successive ruling governments. For instance, even as early as the 1940s, the Belgium colonial administration issued several measures to address this problem by introducing high yielding varieties of cassava, maize, sweet potatoes and potatoes and promoting soil protection against erosion and manure application (GoR 1987b). By the 1970s, socio-demographic issues gained greater traction in the policy arena. In 1974, the National Republican Movement for Democracy and Development (MRND, original in French: *Mouvement républicain national pour la démocratie et le développement*), the ruling political party at the time, created and commissioned a scientific advisory group to study and find policy solutions to the problems arising from overpopulation. This consultative panel later became the *Office National de la Population* (ONAPO) in 1981 (GoR 1990a).

While fundamentally, other social and political issues were at the heart of the problem, the government considered low productivity as being primarily responsible for the lack of agricultural development (GoR 1990a, 2007a; WB 2007). The emphasis on crop yields and outcomes of productivity reflects the government's endorsement of the conventional intensification approach. The government's vision of intensification diverted the policy debate away from the core issues of land redistribution, overpopulation and the undiversified economy, and instead, shifted the burden of production and economic development to the farmers. The combination of rapidly rising population densities and decreasing smallholder production capacities provided a compelling case for the development practitioners and policy makers to adopt an evolutionary model of agriculture intensification. However, several issues

²⁰ According to the Food and Agriculture Organisation of the United Nations (FAO), "arable land is the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). Data for "Arable land" are not meant to indicate the amount of land that is potentially cultivable." For more details, visit the FAO Statistics Division link [<http://www.fao.org/faostat/>].

arise with important implications when governments take rapid and radical production intensification measures indiscriminately.

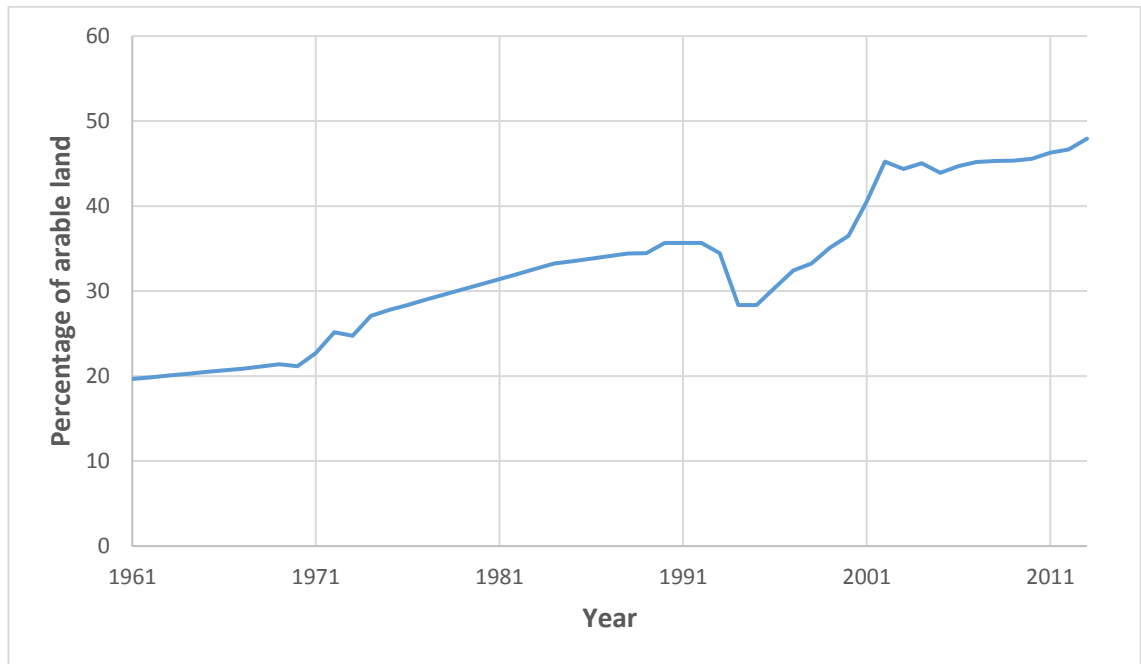


Figure 5. Change in proportion of total arable land from 1961 to 2013 in Rwanda

Source: Data from World Data Bank, *World Development Indicators* (World Bank 2017)

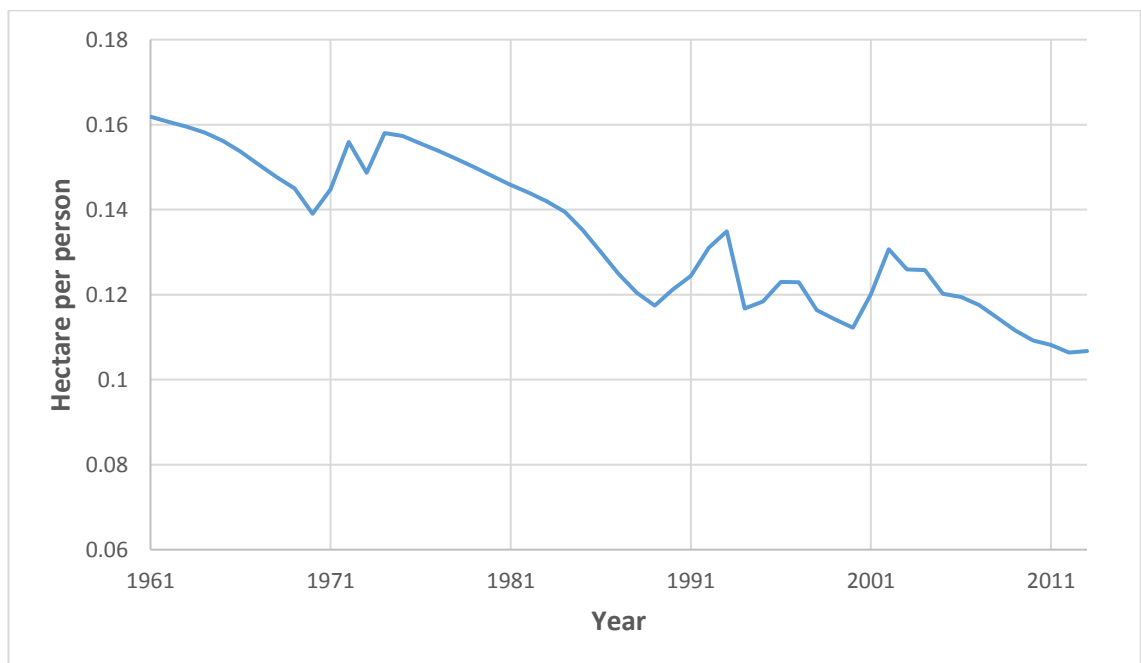


Figure 6. Change in size of arable land per capita (in hectare) from 1961 to 2013 in Rwanda

Source: Data from World Data Bank, *World Development Indicators* (World Bank 2017)

Part II: Findings

Chapter 5. Agriculture Development Policy in Rwanda

Chapter summary

This chapter is about the evolution of Rwanda's agriculture development policy. It draws on archive materials found at the Agricultural Information and Communication Centre (CICA, a French acronym) in Kigali, Rwanda and the British Library for Development Studies (BLDS) at the University of Sussex, UK. The chapter focuses in particular on the policy objective of crop-livestock integration as a sustainable intensification strategy to improve productivity and market participation of smallholder farmers.

Introduction

Given the central role of the agriculture sector in the country's economy and development, the current policies in Rwanda are geared towards a rapid transformation of agriculture production systems (and by extension the farmers' knowledge, attitudes and practice and their livelihood) from subsistence farming to becoming a modern, commercial agro-industry. The call for modernisation and rapid transformation of agriculture is nothing new as similar policy discourses and rural development agenda have reverberated since the early 1960s. The question is therefore asked why, despite the long-standing plan for modernisation and transformation of the agriculture sector, has the widespread adoption and expected benefits of highly intensive production practices by smallholder farmers remain unfulfilled? Some scholars argued that the ways smallholder farmers could partake in such an 'agriculture revolution' have been too narrowly defined and that there seems to be a disjunction between the policy goals and the rural realities (Ansoms 2008; Huggins 2013). At face value, most would agree with the critics that some of the government's objectives are overly ambitious and that the farmers lack incentives and means to partake in the development agenda. What is unclear in this analysis, however, are the factors that drive a wedge between the government's vision of agriculture and the farmers' livelihood strategies and realities. One possible reason, as is argued in this chapter, is the lack of historical and political context within the Rwandan agriculture debate. For instance, the regional politics of the 1970s and 80s paved the way for the regional development plans that are still applied today. Similarly, there is a long history of technocratic thinking in Rwanda that reduced fundamentally social and cultural issues to technical details. Therefore, the agrarian transformation in Rwanda will not be complete

without addressing the underlying social and political nature that guides and motivates farmers to partake (or not) in the government's vision of modern agriculture.

I develop the argument of the chapter as follows. Firstly, I explore the main directions of agriculture development policies from Independence in 1962 to the present, looking mainly at the policies related to integration and intensification of crop and livestock production. The policies promoting the integration of crop and animal husbandry are of interest because the agenda brings together and attempts to solve the common issues shared by both the governments and the farmers, the tackling of poor soil fertility and malnutrition. Secondly, I review several key policy cases to highlight the elements of continuity and change in crop and livestock production policies over time. Through an in-depth reading of the policy and government documents, I also trace the changing social and political dynamics and narratives. Some of the questions addressed and discussed in this chapter are as follows: what are the underlying assumptions made by the government and what are the structural conditions that subjugate smallholder farmers to the notion of intensification through integrated mixed farming; and what are the various elements of continuity and change in the agricultural development policies that can explain why some policies have continued while others have changed or dropped out over time? Lastly, the chapter concludes with the reflection on the evolution of agriculture policies and reforms and compares how the past strategies and experiences relate to the present-day agriculture issues in Rwanda.

Agriculture development in Rwanda

As we have seen in chapter 4, three major, interrelated issues have affected the country's social and economic development agenda since Independence. Firstly, the population growth rate has outpaced agricultural production, secondly, the diminishing size of arable land per household despite the area expansion projects, and, thirdly, persistently low farm productivity and national food insecurity. In this chapter, attention is turned to the agriculture policies that the first two post-independence regimes (1962-73 and 1973-94) and the current government (199– present) adopted in response to these social, economic and political pressures. Broadly, all three regimes have put forward two overarching policy objectives to tackle the problem of rapid population growth outpacing farm productivity: converting more land for farming (expansion) and promoting more productive and intensive use of land through modern agriculture practices (intensification). Table 7 summarises the expansion and intensification policies and programmes promulgated by the first two governments. While the listed policies

and programmes seem to fit neatly into a matrix of themes and timeline, policies interact with each other and influence one another by complementing or competing for the interests of various stakeholders. Therefore, for the analysis, the crop-livestock integration strategy will be compared across time, throughout the changing regimes and in conjunction with other policies and programmes such as the broader development agenda.



Picture 2. Sample covers of the archives from left to right (1964, 1974, 1983a)

Table 7. A summary of agriculture and rural development policies 1962–1994 in Rwanda

Major events	The 26 th of October 1962, Independence; The 5 th of July 1973 Coup d'état	The 5 th of July 1973, a Moral Revolution; Period of relative security & development	Food shortages in 1988; RPF Invasion in 1990
Official development plans	The First National Development Plan (1967)	The 1 st and 2 nd Five-Year National Development Plans (FYNDP) (1973-77 & 1977-81)	The 3 rd and 4 th FYNDP (1981-85 & 1985-89); the Structural Adjustment Programme
Policies & strategies	<i>First Republic</i> 1962 – 1973	<i>Second Republic</i> 1973 – 1981	<i>Second Republic</i> 1981 – 1994
<i>Crops (staple)</i>	No specific policy for staple crop production mentioned. High demand for food crops & relatively high food prices favourable to farmers, but detrimental for government-led industrial (export) crop production.	Production intensification and diversification of food crops prioritised for national food and nutrition security (GoR 1977a). Commercialisation of food aid (wheat flour) by state enterprise OPROVIA in 1977-85 (Nshimiyimana 1987). Expansion of import-replacing staple crops (e.g. soya, rice, and sugar cane).	The President Habyarimana dedicated 1984 as the year of food crop production ; food (in)security considered as the no.1 national priority (1984d). Six crops targeted for the Regional Crop Specialisation programme: beans, green peas (legumes); sweet potato, potato (tuber & root); sorghum and maize (cereal).
<i>Crops (export)</i>	Mandatory planting of export crops in the Paysannat settlements including coffee, tea, pyrethrum, cotton, etc. Government investments in coffee, pyrethrum, tea , paddy rice and sugar cane productions.	Steady growth and reinvestments in traditional export crops (coffee, tea, pyrethrum, cinchona); and new investments in other minor export crops as diversification strategy (tobacco, barley, sisal, sunflower [oil], ornamental flowers, etc.).	National economy highly volatile in relation to international coffee price cycle: boom (1985) and bust (1987-89); followed by Structural Adjustment Programme and austerity policies. Huge deficit in coffee tree stocks; tea production increased from 1987-1990, but increasingly facing quality problem. Investments in the pyrethrum industry continued but production in decline and with no value-adding capacity (1986d).

<p><i>Livestock (cattle)</i></p>	<p>Number of cattle peaked in 1971 (748,000) but decreased due to shrinking pasture land, shortage of feeds, and low animal productivity.</p> <p>Manure from one cow to ideally two to three cows per household envisaged for intensive crop production in the paysannat settlements (1969).</p> <p>Only dairy production deemed economically viable for intensive feeding regime (zero grazing); meat production only viable under extensive or semi-grazing feeding.</p>	<p>Cattle numbers curtailed by the losses of pasture land and lack of alternative feed.</p> <p>Policy focus shifted from increasing the number of heads to adding value per animal (productivity).</p> <p>Artificial insemination centre in Kigali started offering veterinary training and public awareness campaigns to farmers (1977b).</p>	<p>Cattle numbers decreased further, as livestock keeping becomes costlier (due to shortage of pasture land) at the smallholder production level (GoR 1985b).</p> <p>A country-wide promotion of semi-grazing feeding regime, except for the regions where pasture, extensive grazing was still feasible (Mutara, Bugesera and east of Kibungo) (1982a).</p> <p>Agenda put forth for increasing animal productivity through genetic improvement and artificial insemination programmes; and better and more veterinary services and nutritious commercial feeds.</p>
<p><i>Livestock (small)</i></p>	<p>No specific policy for small livestock production mentioned.</p> <p>Strong growth rate in goat production (over nine per cent per year) from 1968 to 1973.</p> <p>Small livestock considered more lucrative as shortage of pasture land constrained cattle production.</p>	<p>Diversification of small animal production other than goats and sheep promoted: pig, chicken, goose, rabbit, etc. contributing to household food security (consumption) and income generation and savings (1977b).</p>	<p>A clear trend of livestock substitution: while cattle numbers decreased, small livestock numbers increased (1986d).</p> <p>Egg production and commercialisation high in demand in rural areas; expansion of National Hatchery in Rubilizi (1982d).</p> <p>Under estimated data for processed and consumed meat as no monitoring and regulations in place for slaughterhouse operations in the rural areas (1992).</p>

<i>Land reform</i>	<p>Paysannat programme launched in 1962: collective agriculture community settlements; for intensification and commercialisation of export and staple crops; by employing modern agriculture inputs and techniques (1969).</p> <p>Other state-run land projects included tea plantations and distribution of reclaimed marshlands and irrigated valley fields for staple crop production.</p>	<p>Villagisation programme piloted in selective areas to gather the scattered population into a central location where state services and infrastructure could reach out cost-efficiently (1977a, 1982a).</p> <p>Arable land expansion: over 235 reclaimed marshland and valley fields projects exploited throughout the country (1982a).</p>	<p>Three broad themes highlighted in land policies: (1) the need for land consolidation; (2) optimisation (efficient use) of the existing arable land; and (3) restrictions on purely financial-based real-estate investment and ownership of farm land (1982d).</p> <p>Major land rehabilitation projects (erosion controlling and terracing) carried out as part of the Structural Adjustment Programme (1990b).</p>
<i>Labour</i>	<p>Each household in paysannat expected to provide an equivalent of three adult labour force; working eight hours per day; equivalent to 6,500 to 7,000 hours per year per household (1971a); also, obliged to undertake collective labour supervised under scrutiny of extension agents.</p> <p>Work is framed as a national duty: “to progress, it is to work for the country to develop and move forward” (1971b: 106).</p>	<p>The Community Development Work programme, locally known as Umuganda, introduced and enshrined in the National Policy Charter No. 23. See (1991a).</p> <p>Umuganda officially budgeted as an <i>in-kind</i> labour investment, representing ten per cent of the total budget of the 2nd FYNDP: that is, worth 5.5 billion RwF (1982d).</p>	<p>Two major issues tackled by labour policies: (1) lack of public education and professional skills amongst the active population, and (2) lack of a sense of entrepreneurial spirit and initiative (1986c).</p>
<i>Research, Extension and Technology</i>	<p>Institut des Sciences Agronomiques du Rwanda (ISAR)’s improved seed multiplication and distribution (<i>Projet Service des Semences Sélectionnées</i>) resulting in a nation-wide uptake of disease-resistant seed potatoes (1965-81).</p>	<p>Interested in domestic production of chemical fertiliser particularly for urea and potassium (1977a).</p> <p>Major projects pursued in the 2nd FYNDP: (1) ISAR’s improved seed multiplication and dissemination, (2) mapping soil characteristics of Rwanda, and (3) building community silos (1977b).</p>	<p>Policies on science and technology for rural development in the 3rd FYNDP had two tiered components: (1) adopting modern technology and high inputs such as tractors, improved seeds and chemical fertilisers, and (2) improving traditional methods of crop and livestock production (1982d).</p>

<p><i>Soil Fertility Management</i></p>	<p>Chemical fertiliser first used in 1967 for industrial (export) crops.</p> <p>Longer periods of fallowing no longer possible, therefore, organic manure promoted as the best soil amendment option for Rwandan agriculture (1969).</p> <p>Calling for recycling of post-harvest by-products such as bean haulm and straws for high quality compost making (1971a).</p>	<p>The 2nd FYNDP problematized rapidly declining soil fertility due to continuous cropping and erosion, and declared the ‘<i>fight against soil erosion</i>’ a priority; increasing use of organic manure and household compost expected (1977a).</p> <p>Chemical fertiliser first used in 1980 for staple crops through the Fertiliser Programme (<i>Projet Engrais</i>) (1986a).</p> <p>The President Habyarimana dedicated 1980 as the year of soil protection and conservation (1986e).</p>	<p>ISAR reported manure and household compost as the best local soil fertility technology suitable for Rwandan farming system (1982d).</p> <p>Greater pressure applied by the Ministry of Agriculture and by local governments to provide training and to enforce mandatory household compost making (1982a).</p> <p>Living fences and contour grass plantings (Pennisetum and Setaria) on terraces encouraged as anti-erosion measure (1982d).</p>
<p><i>Fodder Management</i></p>	<p>Calling for reusing post-harvest by-products such as banana stems, sweet potato leaves, and oil cake as animal feed supplement.</p> <p>Three major grass species advocated by the government: Pennisetum, Tripsacum, and Setaria (1971a).</p>	<p>The government estimated 600,000 hectares of reserved pasture land needed for national livestock development (1977a).</p> <p>Nascent development in the animal feed manufacturing sector, growing along with the soya and groundnut oil mill factories (1977b).</p>	<p>Introduction of forage plants such as velvet beans (<i>Mucuna pruriens</i>) and green manure (vetch grasses) (1982a).</p> <p>Anti-erosion grass plantings considered ‘<i>non-negligible</i>’ and important for animal feed.</p> <p>Zero grazing envisaged for intensive crop and livestock production (1983c); but no land available for dedicated fodder production (1983d).</p>

<p><i>Crop and Livestock Integration</i></p>	<p>Policies for paysannat settlements described integration of crop and livestock (using organic manure) and household compost making as ‘indispensable’ for rational (modern) agriculture production and intensification (1969).</p> <p>ISAR launched experimental studies and demonstration farms to explore intensification models with and without livestock.</p> <p>Dairy production as a ‘<i>two in one</i>’ solution for land constrained, crop-livestock producers: providing commercial opportunities and protein diet for the household (1971a).</p>	<p>The 2nd FYNDP emphasised a combination of cash and staple crop production intensification for smallholder farmers: a mix of 20-30 per cent cash and 70-80 per cent staple crops recommended.</p> <p>Government’s most recommended intensification pathway promoted crop-livestock integration with cattle (ideally), but also with goat and sheep (1977a).</p> <p>Experimental plots and demonstration farms disconnected with the local farming conditions: a middle way approach called ‘improved traditional production’ model proposed by extension researchers (Sauvé 1980).</p>	<p>The 3rd FYNDP forecasted increasing trends of milk consumption and manure application; thus, demanding greater integration between crop and livestock productions (1982d); major research concluded that integration of crop and livestock production (with one cow or with small livestock) a necessity; however, shortage of cattle extended the policy to include small livestock manure (1983c, 1983f).</p> <p>An integrated ‘Farming systems’ model introduced for understanding the complex agro-ecological and socio-economic environment of smallholders in rural areas (1984e).</p> <p>Quality prioritised over quantity: strong policy backing for genetic improvement and artificial insemination programmes (1983a); however, increasing livestock numbers urgently needed for maintaining a steady supply of manure required for crop intensification (1992).²¹</p>
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²¹ In Table 7, unless the author name is specified, the author of the documents is GoR (Government of Rwanda).

The First Republic (1962-1973)

Historical and political context

The government of the First Republic faced tremendous challenges on all fronts – political, social or financial – after taking over the century-old Tutsi monarchy and the Belgium colonial administration. Politically, President Grégoire Kayibanda and his party, *Le Mouvement Démocratique Rwandais / Parti du Mouvement pour l'Emancipation de Bahutu* (MDR-PARMEHUTU), made no attempt at reconciliation with the other political parties who had moderate or accommodating views on the old Tutsi leadership. The government adopted an 'exclusivist' approach to monopolise the political power and social order (Mamdani 2014: 127-9). Socially, people were deeply divided. Newly independent Rwanda was no longer safe for the Tutsi, and many were forced to leave the country in the early 1960s. The exiled Tutsi community hoped for the return and share of power, and some of them chose to fight against the government. The Tutsi guerrilla (infamously called *Inyenzi* by the Hutu parties) made several attempts to return forcefully.²² However, the ensuing reprisals resulted in thousands of Tutsi civilian casualties who were in Rwanda, and the distribution of spoil amongst the Hutu population (Lemarchand 1970: 217-9). The political turmoil in 1959-1962 marked the beginning of the many ethnically motivated acts of violence and retribution, and displacements and repatriations of both Tutsi and Hutu people in Rwanda and Burundi (Lemarchand 1970; Malkki 1995). Finally, financially, the government struggled to start-up the day-to-day administration of the country. All the financial and administrative bodies and functions once shared with Burundi (while under Belgian administration), had to be created anew. Moreover, the military forces required immediate and unconditional budget support. Another pressing priority was the need for modern buildings to house the government organisations and the infrastructures to facilitate economic development. All these required money, of which, the government had none from the outset. So, the government turned to the International Monetary Fund and other countries for loans.

The early years of the first administration were mainly devoted to establishing the government apparatus. Organisational structures and functions proliferated within the ministries. In 1962, the ministries of agriculture and livestock (at the time they were a separate entity) comprised of eight units. By 1972, the two ministries were merged and broadly restructured into six

²² It means 'cockroach' in Kinyarwanda. It was a term used to dehumanise the Tutsi people by the Hutu governments.

departments which in turn branched out to 34 sub-departments – more than quadrupling in the number of divisions (GoR 1983a). With the essential administration having been established and operating, the government turned its attention to strategic planning for the economy. The government's first national development plan had three objectives. The first was promoting agriculture development; the second, increasing fiscal revenues through more (agriculture) exports and (food) imports substitution, and the third, improving and consolidating the administrative, economic and financial structures of the government (GoR 1974, 1982a). The government had high hopes for agricultural development, as the sector could help develop the country's two most valuable and readily available resources of arable land and people's labour.

Crop policies

At the beginning of independence, Rwanda was an agrarian state. With over 90 per cent of the population classified as peasants,²³ and with agriculture and livestock being the primary economic activities for the people and the country (GoR 1983a). Traditionally, farmers cultivated various staple crops for consumption and cash sale, and some produced industrial export crops as part of the colonial, and later, state-run projects. The main food crops grown in descending order of production tonnage, were banana, sweet potato, sorghum, cassava, beans, potato, maize, peas, finger millet, wheat, and groundnut (GoR 1964: 20). Many food crops were also sold locally for cash such as sorghum and banana which were used extensively for brewing traditional beer, as well as beans, cassava and sweet potato. Similarly, the major industrial, export-oriented crops were in the order of production tonnage, coffee, pyrethrum, tea, barley and cotton.

Right after Independence, food crop production grew substantially, whereas the export crops plummeted. For instance, 42 per cent increases in the total food crops between 1959 and 1962 derived from sorghum, maize, sweet potato and banana, which were all local staples. During the same period, the total production tonnage of industrial crops – especially coffee – dropped 66 per cent (GoR 1964: 25). The changes in preference for food production over export crops were thought to be due to a combination of the lax transition of administrative regulation for export crop production and the more independent-minded farmers choosing to cultivate the crops that mattered to them the most especially those which satisfied both their economic

²³ The United Nations' Demographic Yearbook enumerated the country's population as 2.13 and 2.70 million in 1953 and 1960, respectively. The population density was estimated to 113 habitants per square kilometre in 1963 (With the assumption that the population grew at around 3.3 per cent per year since 1960) (GoR, 1964: 13-14).

and household food priorities (GoR 1982a: 10). The high demand for food crops and their relatively high prices in the local market provided positive incentives for the farmers to grow more food crops, but it conflicted with the government's (second) plan for the export-oriented agriculture sector and economic development (see *Crops-staple* in Table 7). The government blamed the high food prices as a deterrent to industrious cropping and farming labour:

Given the high prices for subsistence (food) products, the profitability of production that could contribute to the real development of the country such as through coffee, tea and meat appeared of less interest to the peasants, who preferred to remain confined to a lower-level of subsistence economy, where the little effort that is required for subsistence production was relatively well paid. Consequently, the increase in food prices had the effect of encouraging the peasants to work and produce less, and keep the country at a level of subsistence economy (GoR 1971a: 4).

From the government's point of view, export crops were more important for the national economy and for tax revenues than the staple food crops. Rwanda had few exportable products, and the already established market infrastructures for coffee, tea and pyrethrum which had been inherited from the colonial regime, provided a significant share of revenue for the government (GoR 1964).²⁴ An example where there was tension between preferences of the government and the farmers was the case of pyrethrum.²⁵ Pyrethrum flower has a natural insecticidal substance called pyrethrin. Pyrethrum in dried form or liquid extraction, commanded a high price in the international markets, and the Rwandan government hoped for further area expansion and investment of the pyrethrum industry. Expansion of pyrethrum cultivation was limited, however, to a particular location: pyrethrum grew best in the cold, mountainous region in the northern province of Ruhengeri. However, Ruhengeri had one of the highest population densities in the country, therefore, finding new land for expansion was impossible. The only other way to expand the production was to convince more farmers to grow pyrethrum. While active promotion and campaigns for pyrethrum may have helped in this task, another government extension programme launched earlier in 1965 created an unexpected roadblock for the pyrethrum plan. The *Institut des Sciences Agronomiques du Rwanda* (ISAR), the state-funded agriculture research centre, improved the production and distribution of potato seedling programme, which had a tremendous success across the

²⁴ The strong push for export crop production by the government was reminiscent of the colonial administrative practice and influence, and this was no mere coincidence. The old colonial ties remained strong after Independence: Belgium and Germany being the two main trading partners for both import and export commodities (GoR, 1964: 31-2).

²⁵ See **glossary** for scientific name.

country, but it was in Ruhengeri, where the farmers adopted this most. The high adoption rate was in part due to its ideal agro-climate conditions for potato cultivation.²⁶

Such a spectacular development has turned the market conditions upside down: from a luxury product once reserved for a limited clientele and commanding high prices, the potato became in three years a staple food of the rural population and its price has collapsed in all markets, becoming cheaper than sweet potato (GoR 1982d: 220).

The extended period of seed subsidy programme and the increasing popular demand made potato a crop of choice. Consequently, the government concluded that “[t]he low yields of pyrethrum recorded in recent years can be explained by the increasing interest shown by the farmers who want to grow potatoes [...] such is the case in Ruhengeri, where potato competes seriously with pyrethrum” (GoR 1982a: 17, 26). On the other hand, coffee and tea production would eventually recover and expand to become the most valuable commodity for the export markets (GoR 1964, 1974).²⁷

While the international coffee price was on the rise from 1965 to 1973, many enjoyed the economic windfall. The economic contribution of export crops to the national economy was substantial. The government reaped 60 per cent of its foreign exchange earnings from only 3.8 per cent of the total arable land (GoR 1971b). Producers who grew export crops benefited in a major way too, and their earnings from selling commodity crops reached on average 34 to 67 per cent of the total household income in 1965-1973 (GoR 1982b: 18). Given the clear economic benefits and the well-established institutional support and infrastructures for the export crops, many farmers pro-actively sought the export market opportunities. However, these lucrative opportunities were limited to the government projects and export programme areas.

The most ambitious of the government's policy agenda initiatives implemented during the first republic was *paysannat*, a collective agriculture settlement where farmers worked to intensify and commercialise both export and staple crops and livestock production. The programme ran for 12 years (1962–1974), and it covered over an area of 96,860 hectares, which represented

²⁶ The Improved seed multiplication and distribution programme (*Projet Service des Semences Sélectionnées*) distributed over 1 million kilogrammes of potato between 1965 and 1981 (GoR, 1982a).

²⁷ In 1962, the main export commodity was cassiterite, the ore of tin. Cassiterite and its derivative products made up 79 per cent of the total export value. Coffee and tea comprised 11.4 per cent of the export figures (GoR, 1964: 32). A decade later, in 1972, the standings in export value between the mineral and agriculture commodities switched over. Coffee and tea occupied 85.3 per cent of the export earnings, whereas mineral extracts earned 10.3 per cent (GoR, 1974: 22).

approximately nine per cent of the total arable land at the time (GoR 1970a, 1982a, 1983a). The *paysannat* offered two hectares of land per family, but in return, the farmers had to abide by specific production methods of the government extension strategies. While the farmers could freely choose the food crops, they were obliged to plant certain export crops such as coffee, tea, pyrethrum and cotton with a minimum of 300 coffee tree plantings per family (GoR 1970a). The rules and conditions of work in *paysannat* were strict. Each working member of the household was expected to work eight hours per day through a five-and-a-half-day week. Moreover, they had to contribute to various collective labour projects such as community building sites and maintaining terraces (GoR 1971a). The vision of the programme, however, was confined to the project areas and did not affect the rest of the rural population. The *paysannat* degenerated after a successful start. The first generation of the settlers had enjoyed the programme benefits entirely, but for the generations afterwards, the problems of land fragmentation caused by customary land inheritance nullified the advantages initially offered, which ultimately undermined the effectiveness of the programme. The *paysannat* programme ended in 1974.

Livestock policies

The dearth of reliable statistics and information on livestock at the national level was apparent during the first half of the regime. The publication of agriculture statistics in 1964 made no mention of livestock production (GoR 1964). It was only towards the end of the 1960s that the data on the animal numbers and the importance of manure in the Rwandan agriculture system started to appear in the official documents. There was no national-level policy for livestock, but the government encouraged semi- or zero grazing feeding regimes for farmers in *paysannat*. The rationale for this system was to improve cattle manure collection, which was directly related to the goal of intensive crop production in the settlements:

The consequential reality of the adoption of intensive farming methods in the *paysannat* settlements is that each farmer must be able to have at least one, and preferably two or three cows, to produce this famous manure, indispensable to agriculture (GoR 1969: 207).

However, the rural reality outside the settlements was markedly different. The number of cattle peaked in 1971 (748,000) and then declined (GoR 1982d: 232). The 1972-73 livestock survey revealed a more detailed look at the herd composition in the country. The total number of cattle in 1972 was 742,512 of which 46 per cent were cows, and less than 1 per cent were bulls (GoR 1974: 12). A similar but less pronounced pattern of male versus female numbers

appeared in the young bull (13 per cent) and heifer (22 per cent) population.²⁸ The choice of getting rid of male calves that were not destined for the meat market nor raised for reproductive capacity was common at the time. “The pasture land steadily retreats before the hoe; only the worst of them survive. Areas that only livestock could reclaim without compromising the soil fertility are thus delivered every year to cultivation” (GoR 1971a: 2). Therefore, keeping the female instead of a male calf was a rational, economic decision made by the farmers who faced the shortage of pasture land and alternative animal feeds.

Meanwhile, the number of small livestock such as goats, sheep and pigs that required less grass feeding than cattle increased significantly over the years. The number of goats increased from 399,599 to 628,301 between 1968 and 1973 (a 228 per cent increase or an average annual growth of over nine per cent), and the sheep population rose by 21 per cent from 201,548 to 243,012 in the 1972-73 period (GoR 1974: 10-1). Pig numbers also increased from 30,735 to 60,003 between 1968 and 1972, but the production was almost exclusively limited to two prefectures of Gikongoro and Butare in the South and the urban Kigali (GoR 1974).²⁹ In spite of the lack of policy support for small livestock production, small livestock numbers grew in response to the shortage of pasture land and economic constraints to rearing cattle.

Government-led livestock sector development only began in the early 1970s. Dairy and leather were the two most valuable animal products that held high potentials for industrialisation. The milk processing plant in Nyabisindu in Butare prefecture (today’s Nyanza district) was the largest and the most modern dairy plant in the country, which was at the same time, a subsidiary company of the Ministry of Defence (MINADEF). The milk plant collected raw milk from the neighbouring regions, and the processed milk found markets in the urban areas in Kigali and Butare. Other notable dairy processing plants were also established in Rubilizi (on the outskirts of Kigali), Gatsinsino (Butare in the south), Mukingo (Ruhengeri in the north), and Musamvu (Kibungo on the east) (GoR 1974: 14). The cow and goat hides were another commodity that Rwanda had a foothold in the export market. The increase in market price of the leather was a positive incentive for growth, but the endemic foot-and-mouth disease and the illegal trading which sought to evade customs duty undermined commercial investments and industrial development (GoR 1974: 14).

²⁸ Male and female calves consisted nine and ten per cent of the remaining total headcount.

²⁹ Pork was not part of the traditional diet, and thus, the local demand in the rural areas was almost nil. Most of the pork meat served the urban markets.

Crop and livestock integration policies

Already in the 1960s, farmers had shortened fallow cycles to accommodate more intensive cultivation. The traditional practice of long fallowing could no longer satisfy the needs of the growing population. A shorter fallowing period and continuous cropping were thought to have increased soil erosion and significantly reduced soil fertility (GoR 1969). The efforts to reverse this trend were very costly for both the government and smallholder farmers:

The application of these modern methods of agriculture will obviously require an increased effort on the part of the peasant. First, he will have to reduce the duration of the fallow by using various methods, for example, from planting forage grasses and green manure to following adequate crop rotation cycles, but above all, he will have to bring back organic materials to the field to restore the soil (GoR 1969: 206).

Besides the pressure to slow down and reverse the effects of soil erosion, the pressing demand for more crop cultivation and animal feed production began to sway the policy direction towards the integration of crop and livestock production:

Maintaining the soil fertility of a cultivated land can ordinarily be ensured by ploughing under and incorporating the green manure, application of compost or if the crop is sufficiently 'profitable', the use of mineral fertilisers. But the only way to recover heavily degraded and depleted soils, which have lost all fertility through repeated cropping, is the application of high doses of farm manure (GoR 1969: 206).

However, manure production directly depended on the availability of pasture and animal feed, of which the government had no plans or means to secure. Pasture land was in direct competition with farmland. Much of the pasture land, previously considered unsuitable for farming, were given up for cropping. Crop cultivation on these marginal lands only yielded short-term benefits as the soil quality degraded with successive harvests. And without the free, open grazing areas previously available for smallholders, farmers could not keep their cows, which in return, created a shortage of organic manure. Without manure, farmers could not fertilise their fields, and consequently, crop productivity suffered. In response, both the government and the farmers searched for more land, which hastened the conversion of other pasture and marginal areas to cultivation. The government tried to reverse the negative cycle by promoting modern fodder production and intensive feeding regimes. In the early 1970s, the Ministry of Agriculture started to promote three types of feeding strategies: (1) open grazing, (2) semi-intensive (grazing during the day and stalling overnight), and (3) intensive zero grazing (permanently stalled in a cow shed). With open grazing, a farmer would need approximately one to two hectares of land per cow a year and another 0.03 hectare for additional silage

production.³⁰ For a cow under semi-intensive management, grazing on pasture during the day and being stalled overnight, the official recommendation was 0.05 hectare (50 m²) of additional grass production besides the pasture land.³¹ Lastly, a cow under zero grazing would need a 0.35 hectare (350 m²) of dedicated grass production plot. In return, agronomists estimated that a semi or zero grazing cow could produce from 2.5 to 4, and even up to 10 tonnes of manure annually (GoR 1969, 1970b). However, the actual grass production level of a given land or dung produced by a cow would vary considerably.

Farmers found other alternatives to supplement the feed, but some gave up their cattle for smaller livestock. With the increasing closure of public grazing land, smallholders had to find alternative sources to supplement the feed. The first option was to grow more fresh grass on the plots – either directly on the plot or around the perimeters as anti-erosion grass strips. Several species of grass and legume were well adapted to the local agro-ecological conditions. Some of the grass species such as *Pennisetum purpureum* were recommended for hillside production, whereas *Setaria sphacelata* was suitable for both hillside and marshland, and *Tripsacum laxum* was ideal for marshland. As for legumes, *Desmodium intortum* adapted well to both sloped and valley growing conditions (GoR 1970b, 1983b). The second option was to make silage during the rainy season with the surplus fresh grass. However, making nutritious, palatable and well-preserved silage was technically demanding and required a significant amount of forage and therefore land. This option would have been better suited to large, intensive dairy farmers than for smallholder farmers. The third option was to feed crop by-products and post-harvest residues. The nutrient content of crop-residue and by-products may be minimal, but the severe lack of fodder during the dry season made this option a viable alternative for some smallholder farmers. For instance, banana leaves, and trunk (actually a plant, pseudostem) were thought to be lactogenic, mainly because of its high water content (up to 90 per cent water) (GoR 1971a). The fourth option was to feed agro-industrial by-products such as maize and rice bran or soybean meal and oil cake, but there were only a handful of commercial feed processors in the country and they were in the urban market centres. While all the above options were theoretically available to farmers, but not all the possibilities could be applied and were adopted by farmers. Faced with decreasing access to (free) pasture land, many farmers switched to zero grazing and kept the number of animals

³⁰ A 0.03 hectare of the plot of grass production would secure a daily equivalent of 15 to 20 kilogrammes of silage per cow for the dry season (GoR 1970b).

³¹ The document did not specify the amount of pasture land required for the semi-grazing regime.

commensurate with the farm size assessed in terms of household fodder production capacity. Increasing demand for food crops and land constraints inhibited cattle production, but it started to open up a new integration pathway using small livestock.

The Second Republic (1973-1994)

Historical and political context

A decade after Independence, the country experienced a second revolution. The struggle that once united both the people and the leaders of the revolutionary movement had become an exclusive power brokering arrangement for the political elites. Power politics plagued the political and ideological stronghold of the MRD-PARMEHUTU, and the different factions emerged along the regional-based alliance, the Hutu of the North versus those of the South. On July 5th, 1973, President Kayibanda and his key political leaders were overthrown in a coup d'état organised and led by the Major General Juvénal Habyarimana (GoR 1983a). After stabilising their position in government, the Second Republic prioritised national development. The former presidency achieved and legitimised its power through the merit of ideological liberation against the old order. But times had changed, and the new government answered to a different calling. At the macroeconomic level, the government inherited a financially weak state with high and rising debts, growing dependence on foreign capital and aid, and the undiversified economy that overly relied on the agriculture sector. Plus, with a weak commercial and private sector, the public sector was practically the only agency that could lead and deliver the country's development agenda. Thus, the new political vision was determined to unlock the economic potentials of each farmer in the rural area by instilling a sense of progressive purpose and patriotic duty to work for the country's second economic and moral revolution (GoR 1984a). The manifesto of Habyarimana's political party, *Mouvement républicain national pour la démocratie et le développement* (MRNDD) captured the essence:

Our movement – adhered by the whole population to the proposed goal – is thus called 'revolutionary', because, precisely, the impulse comes from within the People, and not injected from the outside. The awareness of national problems must be extended as an impetus and not as an imposition from above. We must convince ourselves more and more every day that we must rely first on our efforts (GoR 1977a: 2).

Socio-economic conditions and land use problems in the rural areas continued to exert pressure upon government. Over the two decades since Independence, the population had grown by 46 per cent, increasing from 2.8 million to 5.3 million people between 1962 and

1981. Annual food production, had kept up with the population growth rate up until the early 1980s, but the production rate started to lag. For instance, the production data from 1962 to 1979 showed that the overall arable surface expanded over 36 per cent, and the total staple production increased 60 per cent during this period (GoR 1982a: 12). Extrapolations from other official data sets, however, revealed that the major staple crop production grew by 37 per cent only, from 2.7 million to 4.3 million tonnes in total output between 1962 to 1980 (GoR 1964, 1982d).³² More realistic estimates of the food output are somewhere in between the range of 37 and 60 per cent. However, the early nutrition surveys pointed out that the typical average calories of the rural diet were below the daily recommended amount for Rwanda (2,100 food calories), and the dietary composition was poorly diversified and severely lacking in protein and fat (GoR 1977a, 1982d). Thus, production intensification and food diversification became the most pressing priority for the government. *Le Plan Quinquennal de développement économique, social et culturel*, or the Five-Year National Development Plan (FYNDP, henceforth, the Plan) was the main policy framework, from which the government devised various national development policies and programmes. The Plan had four overarching development dimensions: (1) achieving national food self-sufficiency, (2) promoting better use of human resources, (3) improving individual and collective living conditions, and (4) increasing Rwanda's international profile and influence in foreign relations.

Crop policies

Thus far, the rural economy generated little surplus capital that was needed for agricultural financing and infrastructure investments. Staple crop production was the single most important social and economic activity for the smallholder farmers: over 90 per cent of households grew and consumed their production, and this occupied 92 per cent of all cultivated lands (GoR 1986a). Clearly, given the sheer number of the smallholders engaged in food production, the economic demand and interest for expanding and investing in staple crops would have been hard to dismiss. However, the financial and commercial industry in Kigali only started to emerge in the late 1960s, and there was no surplus reserve of capital for agricultural investment. Consequently, subsistence-oriented farmers had no recourse to the formal credit market and had very limited cash to purchase the necessary inputs to invest in intensive crop production. One of the few ways for farmers to tap into financial capital was through government sponsored projects. However, the projects were mainly for export crop

³² The major staple crops recorded on data were the banana, bean, green pea, groundnut, soya, sorghum, maize, millet, wheat, rice, sweet potato, potato, cassava, taro and yam.

production. Coffee was the biggest export commodity (making up to 75 per cent of all export revenue), involving over 275,000 producers. Coffee production levels soared over 130 per cent in cultivated areas and over 200 per cent in output volume from 1962 to 1979, from 17,190 to 23,596 hectares; and from 12,789 to 29,788 tonnes, respectively (GoR 1982b). For tea production, the expansion was even more impressive. The cultivated area increased thirteen-fold, from 600 to 3,167 hectare, and the output jumped nearly nineteen times from 300 to 5,696 tonnes during the same period (GoR 1982b). The rapid expansion in export crop production was a result of factors of push by the government and pull by the farmers. However, in the late 1970s, there was a drastic change in the government priority that shifted the attention from export cropping to food production. In the rural areas, the arable land size per household decreased substantially with the rise in population. For instance, in 1970, a typical family in Gatovu in Ruhengeri Prefecture farmed on average a hectare of land, of which food crops occupied at most 65 per cent of the area (GoR 1978). Most of the families had less than a hectare of land for food production. Crop yields entirely depended on the weather conditions, and the harvest fluctuated year by year. Without adequate storage and warehousing capacity, farmers faced high food uncertainty and risks, which meant that the country as a whole had no buffer stock to sustain a crop failure. The government prioritised food self-sufficiency as a national priority. The sense of emergency and the seriousness of potential food crisis dominated the policy narrative: “the intensification of subsistence agriculture is imposed [upon us]; it is a matter of survival” (GoR 1977a: 67). However, the policy narrative invoked more of a sense of urgency than fearmongering, and the government framed the country’s food security crisis as a point of departure for modernising agriculture sector:

[Thus far,] the increase in food production was achieved solely through the colonisation and recovery of new land. Now, this possibility is rather utopian, as only a few areas are remaining for reclamation (some swamps), and they will not be able to resolve our problems significantly. After 20 years of extensive agriculture, the watchwords are agricultural intensification through intensive use of agricultural inputs (GoR 1982a: i).³³

With the government’s logic of scarcity, however, came modern technological policies. The government became adamant about the superiority of modern agriculture practices over

³³ Although the government argued that the yield gains achieved from land expansion projects were nearly all exhausted, the incumbent government initiated over 230 new expansion plans during the mandate (GoR, 1982a: p.15).

traditional methods. It was during the second regime that the terms ‘rational’ and ‘irrational’ started to appear in the official documents such as ‘irrational farming practices’ and ‘the use of rational farming techniques (i.e. intensification)’ (GoR 1982a, 1985b). By ‘intensification through intensive use of agricultural inputs’, the government specifically meant using (both organic and chemical) fertilisers, pesticides, improved seeds, modern farm equipment; and incorporating anti-erosion techniques, crop and livestock production integration, and crop rotation with green manure crops, etc. (GoR 1977a). However, it was one thing for the government to prescribe these solutions, but it was a different thing to expect the farmers to put them into action. Most of the agriculture inputs required forward investment, but also, effective infrastructure networks and functioning markets, provided that the intensification efforts were economically viable for the farmers. Although the government provided many of the inputs and services through subsidies, the financial and logistical supports were insufficient for scaling-up. Notwithstanding the challenges of intensification, the government stressed intensification over a diversification strategy:

Each farmer seeks to produce not only the maximum quantity but also tries to diversify production by planting as many crops as his family desires to eat. On the field, there will be a range of intercropping as if the farmer does not care much about the crops that would yield the maximum net profit per unit of inputs (GoR 1986b).

The government tried to bridge the competing demands of the intensification and diversification strategies through the ‘regional crop specialisation’ programme. The idea behind the plan was to identify and promote the food crops that were most suitable to the local agro-climate conditions and soil characteristics. The goal was to maximise the return on investments of the crops that had the best natural advantage and commercial potential for intensification (GoR 1982d: 211). According to ISAR’s classification, Rwanda had three agriculture zones conforming to according to low, medium and high altitude, which comprised of twelve agro-climate regions defined by differing soil characteristics and the amount of precipitation. Six main crops emerged as most important for food security in Rwanda: beans and green peas (amongst legumes), sweet potato and potato (tuber and roots), and sorghum and maize (cereals). The government carefully framed and defined the goal of regional crop specialisation, as ‘optimisation’ and not intensification:

We support [localised] optimisation of regional production, which follows the crop specialisation strategies that are most suitable to the agro-climatic characteristics of the regions. The need to increase productivity must not be at the expense of food security, which means that it is necessary to

maintain some degree of diversification. Therefore, we will not advocate monoculture (GoR 1982d: 106).

This distinction concealed two important points. First, the government knew that it could not afford the full requirements of inputs for rolling out a large-scale monoculture project, but also, the success of the regional crop specialisation programme directly depended on the voluntary consent of the farmers who preferred diversification over intensification strategy.

Land policies

The question of land was inseparable to the question of crop production intensification. However, tackling agrarian reform in a country where land was at a premium would have been both politically and socially sensitive. Initially, the second government focused on three areas of intervention: (1) fully exploiting the productivity potential of the land; (2) limiting land ownership for non-farming purposes; and (3) land consolidation (GoR 1982d: 142). All three objectives were long-term in nature and required concerted policy interventions and efforts from multiple domains such as rural development, land rehabilitation, and labour mobilisation.

An example of such interventions was the *villagisation* programme. A new village settlement (not to be confused with the agriculture settlement of *paysannat* popularised during the First Republic) was proposed as a pilot in a less densely populated area in the Sake commune, Kibungo Prefecture in 1981. The rationale behind *villagisation* was to group the scattered habitations into a central location where state services and infrastructure could be provided cost efficiently, but equally important was “to liberate the [fragmented] farmland, thus making farming easier and more productive [on a larger scale]” (GoR 1983a: 27). Thus, ultimately, ‘liberated’ farmlands could be consolidated for large-scale crop production through land consolidation.

While the idea appeared sound, the costs and implications of mass displacement and reconstruction of houses were practically impossible to apply in densely populated but randomly housed areas. The logic of the programme appealed most effectively to young people who had no land and applied only in less densely populated and undeveloped areas. This limited the policy’s applicability and success outside the pilot villages. Another example of the important land reform implementations was the ‘land rehabilitation’ project. As a part of the strategy to fully optimise land productivity, the government continued to expand the arable areas by draining marshlands, rehabilitating less-densely populated areas, and undertaking large-scale hillside terrace projects. The land rehabilitation programme was worth

1,361 million RWF and represented 14 per cent of the total rural development budget of the Second Plan (GoR 1977b: 31).

While the scale of the investment matched the government's commitment and ambition to tackle the question of land, the distribution of project investments was overly selective (if not discriminatory). Out of the whole country, Byumba Prefecture in the Northern region received 93 per cent (1,271 of 1,361 million RWF), and the rest of the Prefectures combined (Butare and Gikongoro of the South; and Kigali) contended with less than seven per cent of the budget (90 of 1,361 million RWF).

The massive land expansion projects required an equally impressive amount of labour. And the government assumed labour power to be abundant. Along with the plan for optimising land use, the government also believed that farmers' labour should be intensified and 'put to better use'. The second overarching objective of the Plan specifically focused on optimising labour resources:

The second mission of the Plan is all the more important because man [labour force] is the country's most valuable wealth, as the potential value of work and production he represents. The fact that [labour force] is still poorly used for tasks for which no training has been given, or it is used for less productive work, or even worse, that it is not used at all, shows how far away we are from the development path (GoR 1977a: 25).

The government did appreciate the farmers' contributions to national food supply: there were many examples of praises for 'prosperous rural life' and 'glorious peasantry' found in the government official speeches [see for example, GoR (1984a, 1984b)]. The government's development policy depended on the contribution of farmer's labour to the national economy. *Umuganda*, the community development work programme, was a manifestation of this logic. In 1974, President Habyarimana officially introduced *Umuganda* as a national programme, through which farmers' (unpaid) work contribution to the state projects became an in-kind labour investment. Farmers' contribution to *Umuganda* officially contributed and was budgeted as ten per cent of the total amount of the Second Plan, which amounted to 5.5 billion RWF (GoR 1982d). Through *Umuganda*, the government hoped to instil a spirit of civic duty and cooperation, which helped to mobilise and capture the unpaid rural workforce for public infrastructure projects such as reforestation and hillside terrace building. Thus effectively combining the first two policy objectives of the Plan, which were to solve the food crisis and use land and labour more 'rationally', through "intensification of agricultural techniques and land management" (GoR 1977a: 24).

Livestock policies

Livestock numbers continued to follow the same trends that we observed during the First Republic. Cattle numbers gradually retreated, whereas small animals such as goats and chickens expanded rapidly and widely (Figure 7).

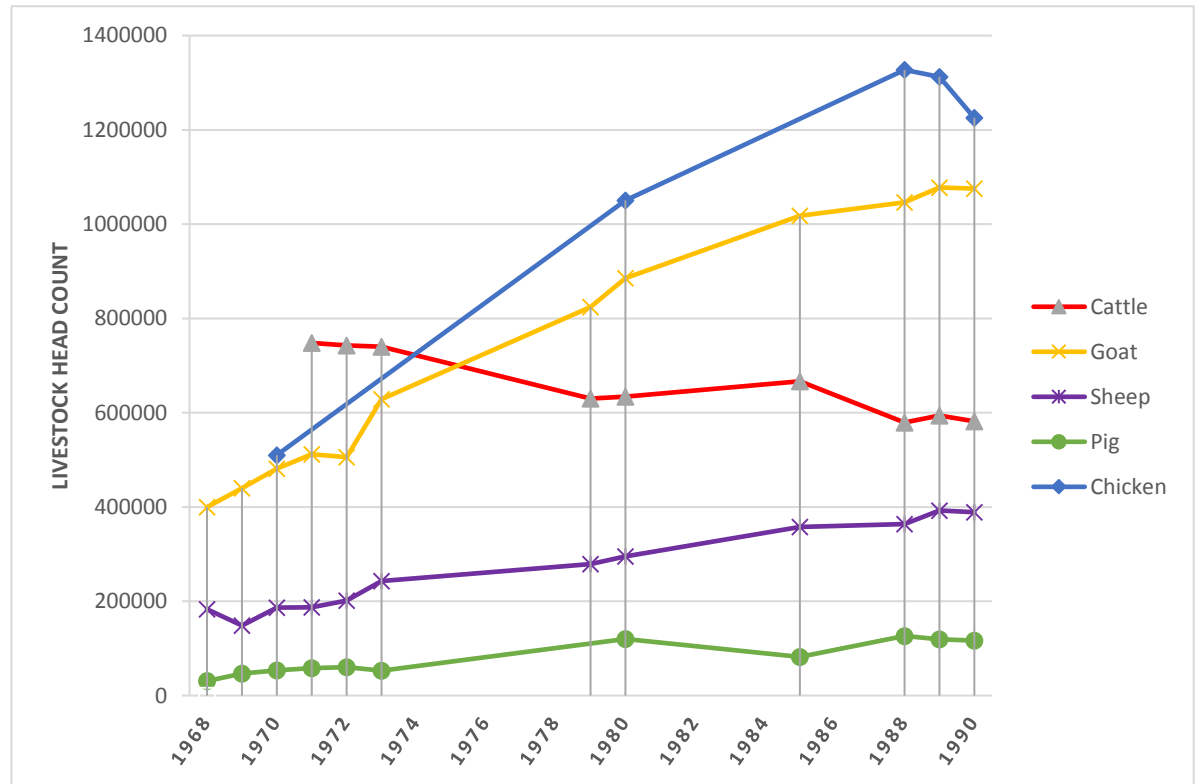


Figure 7. National livestock inventory from 1968 to 1990

Source: Compiled from datasets of GoR (1971a, 1974, 1982d, 1992)

The main causes for the livestock substitutions were the shortage of pasture lands and lack of alternative sources of feed. By the early 1980s, only the herds in low-lying altitude zone in the Eastern regions such as Mutara, Bugesera and Kibungo, could afford to graze in pastures, while the government recommended semi or zero grazing regimes for the rest of the country (GoR 1982a). Instead of directly tackling the root causes of feed shortage, however, the government relied more on the technical approach. Again, similar to the crop policy strategy, the government focused on increasing and optimising the ‘theoretical’ productivity of animal production through genetic improvement and modern veterinary practices and services.³⁴ The

³⁴ I am making a distinction between the experimental yields obtained in a controlled environment (which are essentially theoretical) and the farmers’ yields in natural rural conditions (which arise from practical implementation).

goal was to maximise the productivity of high yielding animals while phasing out the low productive livestock, that is most of the indigenous breed:

As for the livestock production, it is well recognised that the development of extensive animal husbandry faces severe constraints inherent to the natural environment, namely the inevitable reduction of grazing land under population pressure. It will, therefore, be a matter of intensification rather than an increase in absolute value [of livestock number] (GoR 1977a: 50).

The fast declining number of cattle did not matter as long as there was a fair amount of high yielding cows that could sustain the domestic dairy supply. For instance, the forecast for the dairy sector in 1986 accounted three models of milk production (GoR 1982d). The 'modern dairy' model (led by parastatal or industrial entities) had the highest commercial potential and the theoretical milk yields. The herd would be composed exclusively of exotic dairy breeds such as Jersey and Friesian cows. The 'improved' production model would be best suited for progressive dairy farmers (large to mid-size commercial operators) and project beneficiaries who were part of research or donor programme, and who had access to subsidised veterinary services and products, and urban commercial markets. Lastly, the 'traditional' production model represented the rest of the small dairy producers who were the majority, and who had none of those mentioned above auxiliary supports or resources to partake in the dairy value chain.

The Second Plan also had several innovative livestock projects planned such as the artificial insemination centre in Kigali where veterinary technicians and farmers would learn the advanced skills and techniques of reproduction management (GoR 1977b: 20). Although the government has made substantial investment in the genetic upgrading programme, this policy focused solely on dairy production and only applied to those who were proximate to the urban markets. Granted that the dairy sector development would help reduce the dependence on imported milk and appease the demands from urban consumers, but the majority of the smallholder dairy farmers were outside the policy realm.

Moreover, the government's priority on the 'quality' of genetic value of livestock over the 'quantity' (headcounts) seriously undermined the rising demand for manure from smallholder crop farmers. Also, there was another underlying socioeconomic factor that aggravated cattle production. Despite the universal need of livestock for manure and soil amendments, the country-wide distribution of cow ownership represented a skewed ratio of 1 to 4 in the 1980s. In other words, almost three-quarters of the households did not own a single cow (73 per

cent); and for the households who did own, 76 per cent of them had one to three cows, and the 24 per cent had over four cows (GoR 1985c).

While the unequal distribution of cows may have been an indication of social inequality, the government provided no further policy measures, recommendations or actions to increase the access and redistribution of livestock more widely. Given the skewed cattle distribution, the role of small livestock became more relevant and important for farmers. Small livestock such as sheep, goats and chicken were less affected by the expansion of farmlands and the reduction of pasture land. The local cost of traditional animal husbandry was 'practically' sustainable. For instance, one can source fodder from the couch grass growing on hedges on the wayside or from temporarily fallowing land for free during the dry season, and the animals were usually tethered on a peg or tied near the house or farm plots and needed little surveillance and herding. The local small livestock production may seem rudimentary, but it was an 'all-weather' bet for farmers. The profitability of this low-input production system depended mainly on the potential productivity of the animals, accessibility and affordability to veterinary care and fodder, and the price of meat received at the local market which was relatively stable in the rural areas. Higher productivity, shorter gestation and reproduction cycles of small livestock were also advantageous for smallholders who could not afford to rear cattle. For instance, compared to the cost of keeping a heifer for one and a half to two years before it can conceive and produce milk and thus be productive, certain small livestock reached maturity in 11 to 12 months.

In the 1980s, agronomic researchers began to notice the positive economic potentials of small livestock production and started to consider them within the smallholder intensification model (GoR 1983b). The Ministry of Agriculture and Animal Resources (1983b) calculated the recommended dietary figures for small ruminants. For instance, a female goat (or sheep) required eight kilogrammes of high-quality fodder grass per day (which equals 2,920 kilogrammes per year). Similarly, weaners (two kids or lamb) for the first four months after weaning would need four kilogrammes of high-quality fodder grass daily (amounting to 960 kilogrammes per year for the two offspring). In other words, a mother goat and two kids would consume almost 4 tonnes (3,880 kilogrammes) of fresh grass annually. The agronomists also estimated the amount of fresh grass that was needed to sustain this model on a hectare of land. If the plot was well manured and fertile, it was estimated that up to 60 tonnes per hectare of grass of production and if the land were poorly fertilised and less productive, one hectare would yield about 30 tonnes. Therefore, to produce 3,900 kilogrammes of fodder

grass, a farmer would need at least 0.13 hectare or a kilometre of hedge grass cultivation (Table 8).

Table 8. Minimum land requirements for sustaining the small ruminant model in Rwanda

<i>Grass grown on</i>	Poor soil	Fertile soil
Plot (hectare)	> 0.13	> 0.06
Perimeters (kilometre)	> 1.0	> 0.5

Source: Author's calculations based on GoR (1983b)

According to this model, a smallholder could potentially manage to keep at least one goat or sheep under the zero grazing diet, by recycling all the crop residues and by growing grass on the plot (a dedicated area of 0.06 to 0.13 hectare) or around the perimeters (0.5 to 1.0 kilometre). In return, the household could expect to have on average two offspring and to collect 1.2 tonnes of high-quality manure for soil amendment per year (GoR 1983b). In another study, the government promoted small animal production as 'anyone can do it' and beneficial to all farmers:

There are no known [reported] cases where smallholder farmers had to give up income-generating activities to take care of small animals. On the contrary, the incomes of smallholder farmers would increase with the raising of small animals, [which is also beneficial because] it would make use of the underemployed labour (GoR 1983d: 217).

The government estimated figures did not take into account, however, the harsher rearing conditions and the resource competing dynamics at the household level. The actual return on small livestock production critically depended on the improved nutrition, timely veterinary care, and reproduction management. Also, the government failed to grasp the nature and function of traditional animal husbandry in smallholder farming system. Smallholders engaged in a low-input livestock production precisely because they could do so with minimum inputs and resources. Therefore, smallholders rarely sought professional veterinary advice and service for their small animal, putting aside the paucity of veterinary services in rural areas, and they seldom used cereal grains (let alone commercial grade concentrate feed) for fattening (GoR 1983b). The more critical omission was, however, the lack of reference to the potential competition for resources with other livelihood priorities such as household food consumption preferences and multi-functionality of crop by-products such as straw for thatching roofs. The government recognised the economic potential and nutritional contribution of small ruminants, but the policy support and investments did not match up to

the level of attention it received. Farmers continued to raise small animals using traditional methods (GoR 1983b).

Crop and livestock integration policies

Agricultural policies moved into centre stage. In a speech delivered by Speech by Major General Habyarimana Juvénal, President of the Republic of Rwanda, on the occasion of the 10th anniversary of OVAPAM project he said;

Food, agriculture and animal productions are, as you all know, the number one priority of our development plan. [...] We cannot stress enough the necessity of combining agriculture and livestock. (GoR 1984a)

This political impetus was underlined in the same year by Mr. Ntezilyayo Anastase, Minister of Agriculture, Livestock and Forestry, on the occasion of the foundation stone laying ceremony for the Ramba-Gaseke Rural Development Project:

The 'Farming Systems' project consists of a deeper analysis of the rural sector. It is a study of the physical environment (soil, climate, water resources), but also, more importantly, of the principal actor of development, namely the farmer and his socio-economic environment, constraints, decision-making and motivation. [...]

Long live the president and the activists gathered in solidarity with MRND!
Long live the marriage of modern agriculture to improved livestock sector!
(GoR 1984d, 1984e)

The notion of integrating crop and livestock production first appeared in the early 1960s, but it was during the Second Republic that the concept fully translated into policy. During the Second Republic, a series of international coffee price boom and bust cycles took a toll on the national budget, and the trade deficits rose rapidly. Despite the uncertainty of global market prices, agricultural export crops were the mainstay of bread for government finances. The Second Plan prescribed an integration of cash crop (devoting 15 to 35 per cent of the land) and food production for smallholder farmers (GoR 1977a: 65). However, the combination of episodic crop failures and the volatility in the international markets eroded the smallholders' interest and trust in cash crops. The food insecurity continued to worsen, and by mid-1980s, President Habyarimana declared national food security as his most urgent and important priority (GoR 1984d). It was during this time that the crop and livestock integration strategy received the most policy commitment and attention. As we can see from the policy statements the integration system was not short of political will. Also, the government branded integration strategy as a practical and sustainable solution appropriate for Rwandan farming conditions.

Environmentally, spreading manure and planting fodder grass along the contours of the terraces were the most effective remedy for combatting soil erosion and infertility. Socially and nutritionally, livestock products could enrich the protein and fat deficient diets commonly found in rural areas. Economically, both the government and farmers shared the common interest in developing the dairy markets.

Despite all the above imperatives, the crop and livestock integration strategy failed to articulate a coherent policy agenda and to bring the two production systems closer together. Conceptually, the idea of crop and livestock integration was simple to grasp, but the integration strategy involved coordination between various ministries, managing overlapping activities and responsibilities and negotiating for funding against other competing policies. Sometimes, trying to solve one issue created other unintended problems as well. For instance, to make up for the loss of pasture lands, the government promoted semi and zero grazing feeding practices, where farmers would use parts of their farmland to grow contour grass strips and (or) cultivate forage grass intensively. Stall feeding was also ideal for collecting the maximum amount of manure onsite. Despite the efforts to alleviate fodder shortages, many farmers reduced the cattle number and increased their small animals (GoR 1977a). With the decline in the number of cows, the quantity of manure produced on the farm also decreased. Therefore, even with the improved manure collection through stall feeding, the amount of organic fertiliser available per farmer fell over time. Another related problem was the distance between the livestock shed and the farmland. With animals stalled near home, farmers had to carry the feed and bulky manure across various fields and often over long distances. Moreover, farmers' knowledge and practice were thought to yield compost of poor quality: "The application of manure and compost are certainly the best ways to recycling and incorporating organic matter back into soils, but often they are poorly prepared or are available in insufficient quantities" (GoR 1977a: 78).

The government's oversight of manure production was particularly detrimental for the crop intensification strategy as organic fertiliser was the most important and readily available source of fertiliser for farmers in Rwanda. For instance, chemical fertiliser was first introduced in 1967 exclusively for export crop plantations (especially tea), and then in the early 1980s, some of the prioritised staple crops (such as rice and soya) received subsidised fertiliser (GoR 1986a). However, the distribution of chemical fertiliser for crop production rarely extended beyond experimental farming stations and project demonstration plots. The government judged that the rural conditions were not 'yet ready' for more wide deployment of modern agricultural inputs:

Given the context of Rwanda's agricultural sector as described above [...], it seems sensible to prioritise the strategy to improve traditional cultivation and breeding techniques for the 1986 Third Five-Year Plan. [We will] continue to devote to modern technology [but] as experimental and developmental phase, which [the deployment] will naturally evolve with the host [rural] environment conducive for technology transfer (GoR 1982d: 210).

The government's cautious decision was a sensible call. For the rest of the population, the government recommended organic manure: "The ISAR's trials on farm manure and compost [inform us that] the application and production of organic fertiliser are currently the most appropriate technology for soil conservation and improving soil fertility" (GoR 1982d: 212).

Therefore, the government emphasised animal manure for kick-starting the crop production intensification process (GoR 1971a). However, while organic manure received such a heroic attention, little was done by the government to help smallholders get and use more organic and mineral fertilisers. For example, directly opposed to the efforts of increasing animal manure production was the government's decision to invest in modernising the dairy sector and genetic upgrading of cow breeds. In this case, the government narrowly prioritised a particular aspect of production, that of milk, over other production functions and services; which severely compromised farmers' capacity and incentive for integration. The number of indigenous cows declined rapidly while exotic cow breeds increased incrementally (depended on agro-pastoral projects). Thus, the overall decline in cattle number resulted in a cut-back on manure supply.

There was also the deep-seated conflict of interests between the government and farmers. Unlike the conventional (prescribed) agriculture extension approach, which was driven by making a number of incremental technical adjustments, the integration approach required deeper understanding of the farmers' unique livelihood contexts – in other words, understanding it as a 'farming system'. The farming system, as pointed out in the statements made by the Minister of Agriculture, was an innovative idea, but it was perhaps ahead of its time. A farming systems approach appeared occasionally in official documents as a useful research method (GoR 1983a: 75), but it never gained enough traction to become a mainstream practice.

Fundamentally, both integrated farming systems and intensification approaches aimed to increase production and improve household livelihood: but they approached it from different perspectives. An integrated farming systems approach was process based, whereas high-inputs based intensification was more symptomatic and results oriented. The integration strategy

helped to diversify and reduce production risks. Conventional intensification strategies sought, first and foremost, the highest potential productivity and profitability. Integration however, increased farmers' resilience, but intensification (also increased farmers' risk) improved the national economy.

These differences, however, were not necessarily contradictory, but rather, a matter of preference and choice. The government urgently needed to redress the macroeconomic imbalance, but at the same time, it had to heed to calls for the intensification of domestic food and animal production. In this context, the crop and livestock integration was a suitable intermediate solution. However, although the government actively promoted the integration pathway, the projects which were actually implemented were insufficient compared to the investments needed in rural infrastructure, farmers' skills and in capacity building. It is worth mentioning here that 93 per cent of the agriculture development budget for the Second Plan came through international aid (GoR 1977b: 28). The multilateral and bilateral monies restrained the government to follow specific loan modalities and protocols, which in return, made it difficult to fund broader development agendas such as the integrated farming systems approach.

The high aid dependency and the pressure to balance the growing deficit led the government to prioritise export crop policies, which provided quick, short-term financial gains, over long term rural development initiatives. For instance, the government allocated 44 per cent of the rural development budget to special projects related to export crops (mainly tea, but also pyrethrum, cinchona and oil crops), whose impacts were geographically circumscribed; while the country-wide water supply projects received only eight per cent of the support. Similarly, other long-term yielding projects such as researching on improved seed development and building post-harvest warehouses only received five per cent of the total budget (GoR 1977b: 28-32).

Another example of the incompatibility between the short and long-term policy priorities that prevented further development in integrating crop and animal production was the case of *Office National pour le Développement et la Commercialisation des Produits Vivriers et des Productions Animales* (OPROVIA), or the state-owned enterprise for commercialisation of food and livestock products. In 1975, OPROVIA began its operations with two mandates: first, to enhance and vitalise commercial viability of local food crops and animal products through purchasing and storage, and second, to handle and manage international food aid (Nshimiyimana 1987). Regarding the policy mandate, the latter objective was an ad hoc

agenda, but in practice, managing food aid became the biggest preoccupation for the government. As we can see from Figures 8 and 9, not all the food aid received was destined for relief. In fact, a larger share of it was sold through local markets, which contributed to funding OPROVIA's revenue (Figure 8).

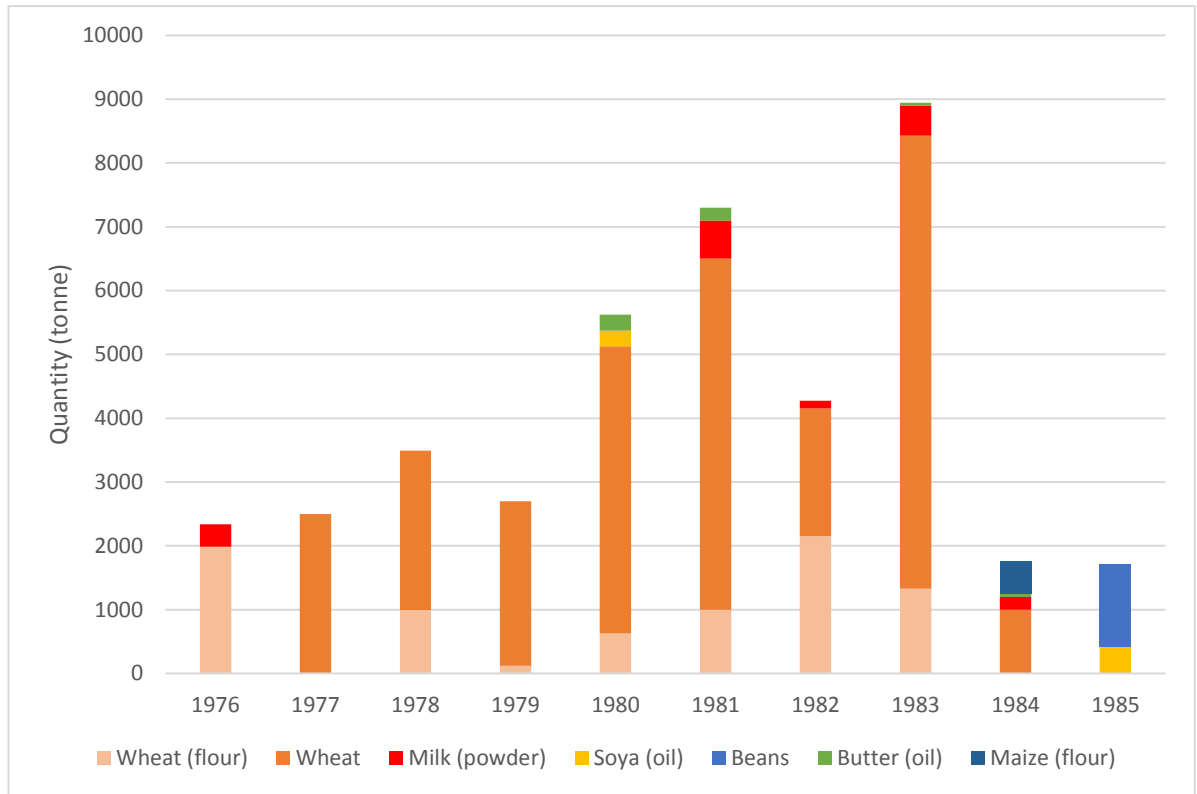


Figure 8. Food aid marketed by OPROVIA from 1976 to 1985

Source: Data from Nshimiyimana (1987: 31)

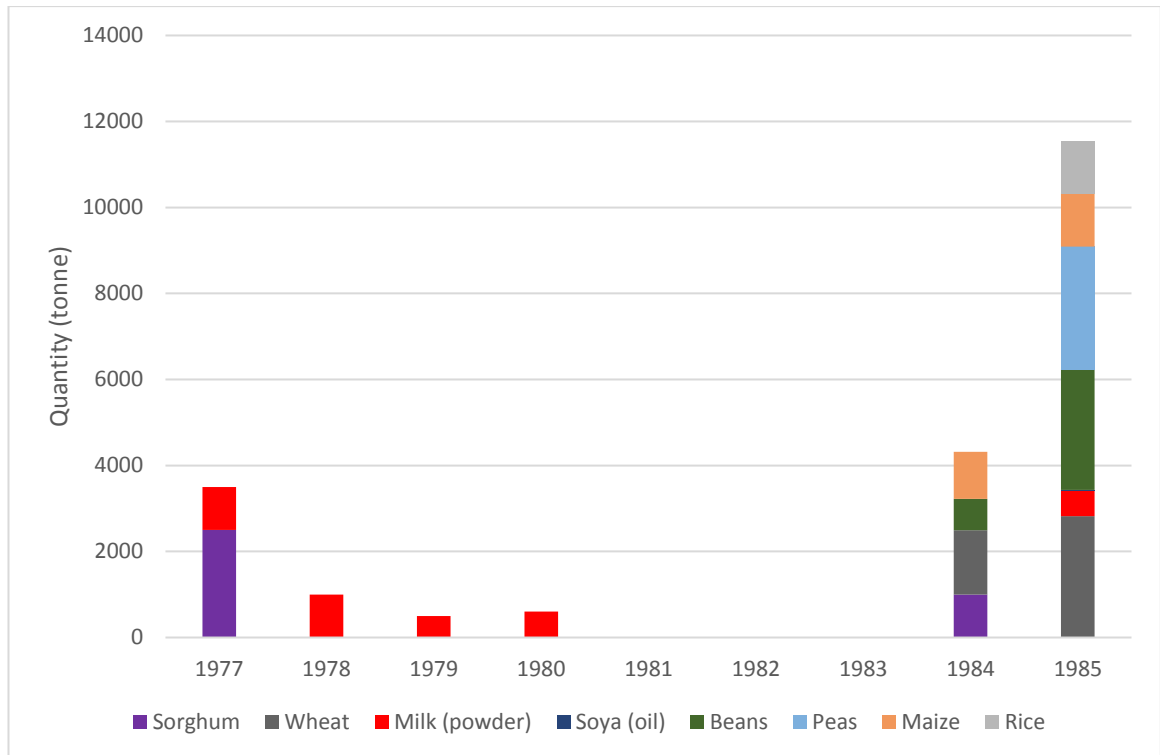


Figure 9. Food aid distributed by OPROVIA from 1977 to 1985

Source: Data from Nshimiyimana (1987: 33)

Generating revenue from food aid was not a problem in itself but selling food products which competed with domestic producers (milk and beans for example), was detrimental to the development of the local market. Worst of all, wheat (both grains and flour) was OPROVIA's biggest promotion product, which exclusively served the urban markets and consumers. The government's choice to commercialise food aid that would only benefit the urban consumers at the expense of the majority of rural farmers (and their development) contradicted (and violated) OPROVIA's first mandate. By the turn of the 1990s, the country gradually became more food aid dependent due to frequent crop failures and resulting famines particularly in the south and the south-west region. Things deteriorated for Rwanda as national economic growth faltered with increasingly volatile export market prices and the increasing pressure to conform to the Structural Adjustment Programme imposed by the international financial institutions.

The 1994 genocide and the post-genocide

Historical and political context

The political situation became acutely worrying in the early 1990s. The threats from the Tutsi diaspora armed group, the Rwandan Patriotic Front (RPF), forced the government to

reconsider the diaspora's demand for returning and the prospect of power sharing. In response, the government increased the military budget to an all-time high at the expense of the state's ability to address widely spreading malnutrition and food insecurity. Farmers' livelihood conditions worsened over time: the average arable land area per capita decreased over the years, and farmers had to sustain an increasing number of family members with lesser resources than the previous generations (Figures 3 and 4). Other scholars have studied the multiplicity of factors and political upheavals that culminated in genocide. See for example, Des Forges (1999); Lemarchand (1996); Mamdani (2014); Newbury (1995); Prunier (1995); Uvin (1998). Detailed accounts of what the genocide meant for farmers are presented in chapter 7.

In this section, we follow up on how the current RPF government's vision of agriculture development addresses the question of crop livestock and land integration that the previous governments dealt with achieving only limited success. We trace the past policy trends and make links with the current agricultural strategies to find the various elements of continuity and change that shaped and influenced the agriculture development until today. From comparing and contrasting their approaches, I hope to elucidate the recurring framings, narratives, themes, strategies and failures.

Starting with the continuing trends: the challenges of land and demographic pressures has not abated since Independence. While the population growth rate has slowed it is still moving in an upward direction, and as a consequence, the arable land area per capita will continue to decrease into the foreseeable future. The two previous regimes achieved growth in agriculture mostly through land expansion. Similarly, the current government also continues to seek expansion in the remaining marginal areas. Contrary to the widespread claims that portrayed the country as having reached the limit of arable expansion, still more areas are being converted for farming and irrigation (GoR 2012b: 4). However, the precarious use of these lands requires ongoing maintenance work by local farmers. In that sense, the land management issues and practices have not changed much since the 1970s. According to the 'Strategic Plan for Transformation of Agriculture in Rwanda' report, over 75 per cent of the cultivated land require some measures of soil erosion control and protection (GoR 2004b). Previously, the governments captured the labour required to perform these tasks through unremunerated, community work and soil restoration activities often performed during

Umuganda (GoR 2009a).³⁵ Today, farmers receive cash for participating in terrace construction from the current government's public work scheme (GoR 2012b). Through this scheme, the government helped to create casual employment in the rural areas and growing more crops on lands that were previously inaccessible. However, growth through land expansion alone would be marginal. Therefore, the current government is combining both expansion and intensification strategies to achieve rapid growth and transformation in the agriculture sector. Several policies reflect the government's vision and strategy that are relevant to the analysis. Namely, they are the Vision 2020 Rwanda, Crop Intensification Programme and the Land Use Consolidation Policy and the National Dairy Strategy.

The Vision 2020 Rwanda and the new vision of agriculture development

All previous Rwandan governments considered agriculture critical for the country's development given its fundamental roles in the economy, employment, poverty reduction and environmental conservation. Governments tackled the low productivity problem on several fronts. The implementations ranged from anti-erosion and hillside management; to collective farm settlements; region-specific crop intensification; semi-intensive cattle production and manure application; and to infrastructure investment in transport routes and markets (GoR 1969, 1970a, 1970b, 1971a, 1971b). Despite the policy implementations, however, agriculture productivity remained persistently low and subsistence-based (GoR 1985c, 1988).

Current policymakers also believe that transformation of the agriculture sector (and by extension the farmers) is a prerequisite for the greater national economic development; and by agricultural transformation, the government means increasing productivity through science, innovation and technology, and commercialisation (GoR 2000). Ideally, professionalised, technology- and market-aware farmers will lead the current subsistence farming sector into a more efficient, productive, and ultimately, profitable enterprise. Therefore, farmers need to be linked, engaged, skilful, well connected and informed about resources, markets and support services (IPAR 2015a). If these are the characteristics of the typical farmer for the future of agriculture in Rwanda, where do the present-day smallholder farmers fit in this picture? Broadly, smallholder production is primarily subsistence-oriented (79 per cent) and manages

³⁵ "Radical terracing is usually done manually with hoes and shovels, mostly by communal group-work involving hundreds of farmers. In Rwanda, a unique method of back-slope terracing originally introduced by missionaries growing wheat in the Northern Province in the 1970s, has been widely adopted by smallholder farmers in many parts of the country. The farmers are careful to isolate the topsoil, then they re-work the subsoil to create the required reverse-slope bench, after which the topsoil is spread over the surface. The riser is planted with short runner grass for stabilization." (Kagabo 2014).

on average less than a hectare of land (80 per cent). Smallholder farming involves raising some livestock (68 per cent of which 47 per cent owned cattle, 53 goats and 45 chicken) and cultivating various staple crops (90 per cent grew dry beans, 76 sweet potatoes, 75 maize, and 52 cassava and potatoes). Often, the heads of household only had primary education, of which 45 per cent are illiterate (GoR 2010, 2012a). The 'glorious peasantry' image once held by the previous governments is no longer present in Vision 2020. Instead, existing agriculture is labelled as 'unproductive' such that smallholders 'can no longer subsist on land' (GoR 2000: 6). What is clear from the government's views on agricultural development is that the subsistence-oriented farming is obsolete. The government is determined to bring the 'peasantry' to an end and instead establish a new order in the rural economy and agriculture sector.

Crop Intensification and Land Use Consolidation Programmes

The Crop Intensification Programme (CIP) and Land Use Consolidation Policy are the results of the government's chief expansion and intensification strategies. Initiated in 2007, CIP seeks to increase the production of 'national priority crops' using inputs (improved seeds and fertilisers) and services, and through consolidation of farmlands and improvement of post-harvest handling and storage infrastructures (GoR 2011c: 13). The Rwanda Agriculture Board (RAB) selected the national priority crops best suited for local bioclimate conditions. Thus, the government can link and mandate specific regional crops to each locality, targeting down to the District level. Currently, the priority crops are maize, rice, wheat, potato, cassava, soybean and beans (GoR 2012b: 3).

The government's crop prioritisation strategy has its origin in the regional crop specialisation programme promoted by the previous governments (GoR 1982b). As such, regional crop specialisation and prioritisation have been a long-standing policy promoted by successive governments. What sets the current approach apart is the commercial and large-scale production aspect. The mass commercial production is crucial for the success of the current agriculture development plan. The current policy prioritises the efficient use of inputs, which is aligned with the government's endorsement of conventional approaches to improving crop productivity.³⁶ For large-scale production, medium and large scale farming can better achieve

³⁶ The Rwandan government is a partner member of the Alliance for a Green Revolution in Africa (AGRA), which is a major agriculture development partnership that channels the funding and technical expertise of various philanthropic foundations (such as the Bill and Melinda Gates Foundation, Rockefeller Foundation) and corporate giants such as Monsanto and Cargill to "help millions of small-scale farmers and their families lift themselves out of poverty and hunger" by "doubl[ing] yields and incomes for 30 million farming households by 2020" (<https://agra.org/who-we-are/>). The success stories of AGRA

production efficiency and the economies of scale than smaller farms (GoR 2012b: 5-6). However, to implement large-scale crop production projects in Rwanda means piecing together the small fragmented land holdings. The government introduced a new law that endowed the state with the direct control over land and by extension choices of local crop production. First, in 2005, the government introduced the Organic Land Law that provided the legal mechanism for the state's access to and control over farmland. The law stipulated that

[t]he State is responsible for managing the state land in the public interest and with the objective of supporting economic development and social welfare. The law further requires that while each landholder retains his or her individual rights to the land, he/she should ensure that procedures for land use consolidation shall respect the order of the Ministry of Agriculture and Animal Resources (MINAGRI) which determines the modalities for land use consolidation (GoR 2012b: 6).

Secondly, in addition to the Organic Land Law, the government introduced the Land Use Consolidation Policy and Programme (henceforth described as the land consolidation programme). By consolidating land use, and not land tenure, the government was able to collectivise many small and fragmented plots into a large-scale farm suitable for monocrop production. Occasionally, if houses were within the land consolidation project zone, the family would be compensated and relocated to another house of similar value in the nearest *Umudugudu* (state built settlement village).³⁷ The setting up and implementation of the land consolidation and crop intensification programmes involved a whole chain of command of various stakeholders – from the Ministry of Agriculture staff to the local government authorities, to the private input suppliers, and to the chief of the village and finally, the groups of consolidated farmers.

The government institutionalised *Imihigo*, an accountability policy and management system for overseeing and incentivising all public servants, for full adherence to the delivery and achievement of the set targets. The Ministry and the local government determined the agreed objectives such as the specific number of hectares reserved for the CIP, quantity of subsidised inputs to be distributed, and expected targets of crop yields, and so on. These objectives

programmes in Rwanda were widely promoted (they have featured on several occasions in *The Guardian*) and the former minister of MINAGRI, Dr. Agnes Kaliabata, joined AGRA after completing her ministerial term 2008-14. She is now president of the organisation (<https://agra.org/who-we-are-our-leadership/agnes-kalibata-3/>).

³⁷ The voluntary nature of the programme and the compensation practice were not always neutral and carried out without problems. See the critiques, for instance, van Leeuwen (2001) and Huggins (2014).

would be legally binding and subject to an annual performance and evaluation contract that tracked each project activity and actor and linked them to the programme results (IPAR 2015b: 8).³⁸

The actors in the *Imihigo* system were the local government authorities and the extension agents (tiered from the District to the Sector and the Cell level). All the extension agents were accountable to the respective line managers for meeting the overall (and their respective) production goals. The cost of failure in achieving the goals was their job (Ntirenganya 2016). At the village level, usually, the head of the village with the help of two to three farmers mobilised the villagers whose lands belonged to the CIP into working groups. The primary role of the local community leader was to facilitate the distribution and monitoring the use of the subsidised inputs at the participating farms. Finally, the subcontracts between the Ministry of Agriculture and the local private input suppliers allowed wider coverage and network for more responsive logistics of agriculture inputs distribution across the rural areas (GoR 2012b: 11).

Since the implementation of the programmes in 2007 to 2011, crop production numbers increased substantially. For instance, maize and wheat increased six-fold, and the potato and cassava outputs also tripled during this period (GoR 2011c). If the increased usage of modern inputs and surplus generation were the sole criteria for the commercialisation agenda, then, all the elements seem to be in favour for Rwanda to achieve the agricultural transformation and modernisation objective (GoR 2013b: 4-5). However, while technological improvements and extension support are vital to the transformation of the sector, the government's singular vision of agriculture development based on a technocratic approach has been criticised for being too rigid and incompatible for most of the smallholders (Ansoms 2008, 2009; Dawson et al. 2016).

National Dairy Strategy

Previously, the livestock policies promoted by the First and Second Republic were rather elementary. Mostly, the policy documents reported on the potential areas for investment and future research that would help spur commercialisation and innovation in the livestock sector. However, despite the invested efforts, there was little evidence of innovation or productivity improvements. The gains made in livestock development during the first two Republic governments suffered a setback during the genocide. The animal population plummeted in

³⁸ *Imihigo* is an annual performance contract signed by all government officials with the President of Rwanda. It is also a performance management tool that puts every public servant accountable for the achievement (or failure) of the local development programmes.

1994: 80 per cent of the cattle, 90 per cent of goats and sheep, and 95 per cent of chicken were slaughtered (GoR 1997).

The livestock sector development policy has seen a significant change. In the aftermath of the genocide, the government stepped in to accelerate the restocking process through artificial insemination and cow transfer programmes. Moreover, there was a renewed commitment to accelerating dairy sector development. The local, long horned *Ankole* breed is sturdy and well adapted but produced little milk. Instead of repopulating with this breed, the government moved to reduce the number of local cows and increase more productive dairy breeds. Local cows were cross bred with high milk yielding breeds such as Jersey and Friesian cows.

The motivation behind the dairy policy was primarily economic. Firstly, dairy is a strategic commodity and the government sought to strengthen the dairy industry by fostering economic linkages and opportunities for both the private sector (for those who provided services and value addition along the milk supply chain) and dairy farmers (GoR 2013a: 10). Supporting local producers would also ease the reliance on dairy imports from Uganda and Kenya. Secondly, given the land constraints for livestock feed production, intensive (zero grazing) milk production would be the most economically viable option for the land-constrained farmers.

Moreover, the economic context of the smallholder farmers often restricted the number of zero grazing animals to one to two. Initiated by the President Paul Kagame in 2006, an asset transfer programme called the *Girinka*, or One cow per poor family, has been distributing heifers to over 200,000 poor (eligible) households (GoR 2006; A. Kagabo 2015pers.comm.).³⁹ The goal of this programme is to distribute a dairy cow to every low-income household, which meant reaching out to a total of 350,000 households by 2017.

While giving a cow to families in need is a noble idea, there remain many hurdles to overcome for the beneficiaries to sustain the sufficient level of dairy production. The shortage of veterinarians and trained para-vets in the rural areas is an overwhelming challenge for the livestock and dairy development in Rwanda. For example, a sector level vet has to serve on average 3,150 cattle across various locations (GoR 2013a). The animal feed industry is another

³⁹ The household must satisfy several criteria to be eligible for the *Girinka* programme. First, the family currently has no cow but has access to approximately 0.75 hectares of land of which a minimum of 0.20 hectares is to be devoted to fodder production. The family must build the cowshed prior to receiving the cow and agree to pass on the next heifer to the next awaiting farmer. Selected beneficiaries are trained by local extension agents (veterinarians and agronomists) in intensive, crop-livestock farming practices. With all pre-conditions cleared, farmers receive a female cow usually of an improved crossed or exotic dairy breed (such as Jersey or Friesian).

important auxiliary sector that is a prerequisite for the livestock development. However, the animal feed industry has only been making headway recently. The government tried to expedite the sector development by attracting investments and adopting private-public-partnerships (PPPs) as a core strategy for the national dairy policy framework (GoR 2013a: 12). The public sector's involvement in the partnership is often prescribed as that of the 'facilitator' – that is, creating a dynamic and enabling environment where private sector-led dairy development could flourish (GoR 2013b). In practice, however, the government actively influenced and guided the demand and supply of dairy markets. On the demand side, the government actively supports the marketing of processed milk products and consumption (as opposed to raw, unprocessed milk traded informally). And on the supply side, the government subsidised artificial insemination programmes for increasing the number of dairy cows, which would bring down the costs of production of milk at the national and industrial level. The push for dairy intensification was one way for the government to help kick-start the domestic dairy industry as the official livestock strategy papers often cited the insufficient milk volume as one of the biggest problems for the dairy processing industry to be price competitive (GoR 2013a). The surplus production of milk would reduce costs and allow the dairy processing industry to operate at a larger scale.

Implications for crop and livestock integration policies

Previous governments considered intensification of production through the integration of crop and livestock farming a crucial and necessary step for the development of the agriculture sector. Integration of production systems was an intermediate step between the subsistence farming and the high input production promoted by the government. Today, the policymakers continue to envision agricultural policies through specialisation and integration paradigm. The vision of the National Agriculture Policy is to vie for "modern, professional, innovative and specialised agriculture; and a [strictly] market-oriented agriculture," but also "integrated and diversified agriculture" that incorporates both agriculture and animal husbandry (GoR 2004a: 9). The sense of urgency (but also confidence) to 'leapfrog' into a modernised and specialised agriculture sector is the hallmark of President Kagame's administration. Some examples of the language used in the policy reports illustrate this: "Sustainable Growth for Jobs and Exports will be driven by an ambitious, high-quality public investment programme..." and "Vision 2020 *Umurenge*, will accelerate the rate of poverty reduction..." (GoR 2007a: i).

While an ambitious political agenda and a firm commitment and political will offer clear leadership in development direction, losing sight of the people's immediate reality raises a

concern. For instance, according to the *Ubudehe* survey, a country-wide participatory poverty assessment, conducted in 2006, identified the causes of poverty by the respondents. They were (1) *lack of land* (49 per cent), (2) *poor soils* (11 per cent), (3) drought and weather (9 per cent), (4) *lack of livestock* (7 per cent), (5) ignorance or lack of knowledge (4 per cent), and (6) inadequate infrastructure (3 per cent) (GoR 2007a: 14).⁴⁰ Amongst these important causes, (1), (2), and (4) – making up 67 per cent of the total – are related to crop and livestock integration. However, the current policies that address the issues of land, soil fertility and animal husbandry are designed and framed more individualistically (conforming to the specialised areas of expertise) than synergistically (as an integrated agenda). For instance, the commercial interests (and the bottom line) of the dairy industry are different to the benefits that smallholder households seek. For example, under production of organic manure and application is a critical concern for nearly all the smallholder farmers with livestock, because the lack of space and soil infertility ultimately undermines the animal feed production, and therefore, affecting dairy production as well. Bridging the dichotomy between the policy goals and the smallholders' realities is important because by failing to do so, opportunities to channel the needed resources to the farmers who can redress the gaps that continue to hinder the rural and agriculture sector development in Rwanda today might be missed.

Conclusion

This chapter investigated the continuity and changes in the development of agriculture and rural development policies in Rwanda. The aim of this chapter was to present an overview of the agriculture policies and strategies that remained relevant throughout the time, but also to highlight the policies that have threaded in and out from one period to another. This overview is relevant because the current government's development policy and modern vision of agriculture demand a fundamental and rapid shift from subsistence to modern commercial farming, of which the previous governments have also tried but failed.

The question may be asked of whether the government's vision of agricultural development is aligned with the rural reality and farmers' needs of today. On one hand, the government has proved itself by establishing and delivering essential public services (particularly in planned housing, education and health sectors), as well as providing security and political stability. Many international observers applaud the success in achieving sustained economic growth and

⁴⁰ The remaining issues (17 per cent) were inadequate technology (2), sickness (2), polygamy (1), lack of access to water (1), population pressure (1), and others (10). Italicised emphases are mine.

development (GoR 2013d). On the other hand, the singular vision of transforming agriculture sector into a modern, and market-driven industry while most of the rural population are largely unaware and inadequately prepared for such transformation is critiqued as 'authoritarian' and 'missing out the poor' (Pottier 2006). My intention here is not to discredit or dissuade the Rwandan governments' optimism and enthusiasm for a rapid and transformative development. Instead, the various accounts and records of the past policies and programmes have been laid out that are similar to the current policies and in an effort to elucidate the trends that may help us to rethink the policies and redirect them if necessary. It is with this critical yet constructive approach that the government's development vision, policies and programmes were appraised in this chapter.

The analysis of previous agricultural and rural development strategies and policies revealed that there is an important element of continuity running through the policies being promoted today. The starting point in the design and framing of all the agrarian reforms was how to end the subsistence-based agriculture and transform it into a modern commercial sector. Also, all previous governments relied on technological upgrading, institutional control over access to land and labour resources, and more recently, the state's direct engagement in the market, which were all inspired by technocratic and neo-capitalist solutions.

There have also been important changes, with some of the policies that were central during the first two regimes being dropped by the current administration. Ethnic-based discrimination and violence eroded social trust and disrupted cooperative arrangements that once held the communities together. Institutional racism has been outlawed since the RPF regime took office. Another major challenge that the RPF government succeeded in solving was the question of land redistribution – which involved the settling of both old and new land holding claims by the returning diaspora and the internal migrants. Huge administrative efforts and investments were quickly pulled together to complete the national cadastre, which effectively registered all parcels of property in Rwanda. Still, as we will see in the upcoming chapters, land continues to be contested in the local villages amongst families and neighbours.

Some new issues and policies emerged with the post-1994 regime. The inherent commercial handicaps of Rwanda because of being a small, hilly and landlocked country, is becoming less of a development impasse with the current government, thanks in part to the public sector's direct involvement in shaping the market through the framework of public-private-partnership. The potentials for agro-industry growth are limited, but with precise coordination and cooperation (although some may object them as micro-managing and coercive), the

government argues that the low agriculture productivity is reversible – as the crop yields from the CIP and Land consolidation programmes suggest. The national dairy policy also showed that the substantial support and active involvement of the government in the sector resulted in rapid increases in milk production, but the majority of dairy producers still face the stifling feed constraints and lacked opportunities for livestock production expansion and intensification.

This chapter aimed to provide the historical background to the question of whether greater crop-livestock integration is an appropriate general strategy to increase productivity and contribute to broad-based poverty reduction at the national policy level in Rwanda. The results of the archives analysis showed that the current government's pursuit of commercialisation and intensification policies that rely heavily on the use of subsidised inputs and agro-industries had produced favourable outcomes. Meanwhile, the development role of smallholder farmers continues to be characterised as being responsible for the underdevelopment of the agriculture sector. Without acknowledging and addressing other related structural and underlying socioeconomic challenges, the positive gains achieved through current intensification policy may be out of reach for many smallholder farmers. The shift from intensification by specialisation to an integration paradigm could potentially open up, or support already existing but neglected, pathways of development that can support and channel necessary resources to the smallholder farmers to transition out from subsistence level farming to commercial value chain. We will continue to explore the question more empirically from the family farm's point of view in the following chapters.

Chapter 6. Comparative analysis of patterns of crop and livestock integration amongst smallholder farmers in Rwamagana

Chapter summary

This chapter addresses the following questions: what are the patterns of crop-livestock interactions and their contributions to both livelihood activities and soil fertility and animal feed management; and what is the evidence base supporting intensification through mixed crop-livestock farming as a viable option for the smallholders in Rwanda? The chapter presents the findings from the household surveys conducted in Gisanza and Umuganura villages, as a case of a rural and peri-urban setting in Rwanda, respectively. The comparative assessment of crop and livestock integration activities and strategies employed by smallholder farmers reveals significant differences. First, similarities and differences in the farming and livelihood activities of the villages help to situate the overarching context and characteristic of each setting. Then, to assess the differential capabilities of the engagement of households in crop and livestock production, I stratify the sample population by their relative economic standing. Ultimately, by identifying various patterns in crop and livestock farming practices and their commercial potentials and limitations, I assess the different levels of farming capacity of households and their tendency for integration and intensification. Furthermore, I analyse various components of crop-livestock integration to reveal the differential productivity, economic viability, social implications and complications of diverse pathways of crop and livestock production in Rwamagana.

Characteristics of the peri-urban and rural villages

Gisanza is a rural village in Rwamagana. It is five kilometres away from the main road, and people usually walk about an hour to reach there (Table 9). The nearest market in Rwamagana is 15 minutes away from the main road using local transportation (mini-bus or motorcycle) or an hour by walking across the valley and the hill. Cycling to town is challenging as the road to Rwamagana is hilly and unpaved. Despite the moderately distant location, the villagers do not consider this to be an issue.

An active community leadership and initiatives are evident in Gisanza. The head of the village is young (35 at the time of the fieldwork), self-motivated and pro-active. He and the village committee members regularly hold meetings to discuss village development plans and projects. For instance, public health awareness is one of the village priorities. Thanks to the

ongoing involvement of the village leaders and the community health workers in promoting the national medical insurance (*mutuelle de santé*), all the villagers have enrolled in the insurance plan for a number of consecutive years. In recognition of this achievement, Gisanza received free corrugated metal sheets and building materials from the sector and district governments. The villagers used the materials to construct the new community hall.

The head of the village also spearheaded several other projects and successfully mobilised people to establish kitchen gardens, hand-washing stations outside the latrines and more permanent animal sheds. The latter initiative was instrumental in introducing the *Girinka* programme to the village. When the head of the village learnt that the representatives of Send a Cow, an affiliated international NGO partner of the government, were scoping the area for potential beneficiaries, he informed and helped the villagers to build and improve their cow sheds and planted grass strips on the contours of the fields. When the representatives of the NGO came to assess the village, they found a large number of households qualifying under the programme criteria and donated 30 cows at once. Moreover, Gisanza has a registered cooperative that collectively promotes milk, banana and maize production and marketing. Furthermore, in 2011, the village cooperative gained access to the valley land (24 hectares) as part of the Land Use Consolidation and Crop Intensification programmes. Forty-two households were participating in this scheme at the time of the fieldwork.

Table 9. Main characteristics of the case study villages

Characteristic	Unit	Gisanza	Umuganura
		(rural)	(peri-urban)
Population (census)	household	136	170
Survey sample size (n1; n2)	household	80	89
Planning zone		Agglomeration	Modern planning
Accessibility by walking	in minutes		
to the major road	mean (std. dev.)	64 (26)	17 (13)
to the nearest market	mean (std. dev.)	59 (21)	32 (17)

Umuganura is a peri-urban village near the central town of Rwamagana. Most of the houses are less than twenty minutes away from the main road and only thirty minutes away by walk from the market centre (Table 9). The village has several successful agri-businesses specialising in egg and pig production, and industrial maize mill and animal feed production plant. The majority of the villagers have electricity (62 per cent) and tap water (40 per cent) connected to their compounds. Umuganura falls under the urban planning zone, and the building code prohibits the use of low-quality building materials such as mud bricks and thatched roofs for the new building.

Unlike Gisanza, there is no pro-active community leadership or organised cooperative operating in this village. However, the centrality of location is an invaluable advantage for the villagers. Having close access to the vibrant local markets and well-connected transportation allows villagers (especially the head of households) to seek casual employment opportunities in Rwamagana town. Also, there are many public and private institutions and businesses nearby such as the Rwamagana District office, hospital, banks, schools (from nursery to university), milk collection centre, restaurants and hotels. Permanent job positions are rare, but short-term casual opportunities are more frequently (but sporadically) in supply. Moreover, the local bi-weekly markets attract large (and steady) crowds of producers, visitors to the market, and distributors from across the district and beyond. All these facilities and business activities are attractive and conducive features for commercially oriented and entrepreneurial enterprises in Umuganura.

Crop and livestock production characteristics

Land use

Farmers in Gisanza cultivated on varying sizes of plots (mean: 2.8 plots), but on average, farmers managed about 0.71 hectares of land (Table 10). On the other hand, farmers in Umuganura cultivated on much smaller size (0.42 hectares) and fewer plots (1.9). However, farmers from both villages walked on average over 15 minutes to reach their plots (Table 10). Most of the cultivated plots are farmer's land (73 and 70 per cent from Gisanza and Umuganura, respectively), but some are rented (15 and 22 per cent). Additionally, others have access to land through usufruct rights (10 and 7 per cent). Farmland in both villages is under intensive cultivation. None of the farmers fallow and they continually cultivate a diverse selection of perennial and annual crops and forages throughout the wet and dry seasons. Many farmers grow food crops and animal fodder on the same plot (71 and 35 per cent). Farmers in Umuganura dedicate more land for monocropping (59 per cent) than those in Gisanza who prefer mixed cropping (24 per cent).⁴¹ One of the main reasons for this difference has to do with the farm size and livestock holding, which will be covered in more detail in the following sections.

The kitchen garden initiative, locally known as *akarima igikonyi*, aims to increase the backyard vegetable and fruit production and consumption in the rural areas. The high rates of household food insecurity and child malnutrition in the country are an ongoing priority for the

⁴¹ See **glossary** for the meaning of monocropping.

government (GoR 2002, 2006, 2011a). Local governments also actively promote and feature demonstration gardens in public institutions such as in hospitals and schools. However, the design of the garden and the choices of the crop are left to the discretion of families. Seventy per cent of the sampled households had a kitchen garden in Umuganura, compared to 79 per cent of families in Gisanza (Table 10).

Table 10. Main characteristics of crop production in Gisanza and Umuganura

Farm production	Unit	Gisanza	Umuganura
		(n ₁ =80)	(n ₂ =89)
Land			
size	mean (std. dev.)	0.71 (1.1)	0.42 (0.6)
	max	7.2	4.3
plots	mean (std. dev.)	2.8 (1.5)	1.9 (1.3)
	max	7	6
time took to reach a plot by walking	mean (std. dev.)	16 (57)	17 (31)
kitchen garden (dummy, 1=yes)	mean (std. dev.)	0.79 (0.41)	0.70 (0.46)
Number of crops grown in			
rainy season A	mean (std. dev.)	8.0 (4.9)	4.8 (3.8)
rainy season B		8.1 (5.1)	4.8 (3.7)
dry season C		4.4 (2.8)	2.2 (2.1)

Crops

The majority of farmers in both villages cultivate multiple crops (growing two or more annual and perennial crops on the same plot in a year). In Gisanza, farmers planted on average eight different crops during the growing seasons A and B (8.0 and 8.1, respectively), whereas in Umuganura, they grew just over half that number (4.8 and 4.8, respectively) (Table 10). The staple grains are maize and sorghum, and farmers often alternate between the two from one growing season to another. Typically, farmers intercrop beans with cereals (either maize or sorghum) and other annual crops (Picture 3). Alongside, farmers also grow a combination of roots, tubers, plantains and bananas throughout the year. The importance of roots, tubers and the perennial banana plants for household food security is most apparent during the dry season (C) when the number of crops drops to about half of what the farmers usually grow during the rainy seasons (Table 10). Farmers especially appreciate cassava for its tolerance to stressful growing conditions and the relatively low input requirements. Plantains and bananas are a local favourite and prized staple, but their long growing cycles and the concerns over banana bacterial wilt in the region make the investment riskier than other perennial crops (district agronomist, personal communication, 17 March 2015). Nonetheless, plantains and bananas are one of the most consumed and traded foods in the region.



Picture 3. Intercropping sorghum and banana (left); intercropping beans and banana (right)

Farmers cultivate fresh vegetables and fruits in their kitchen gardens. Fresh cassava leaves (*isombe*) and local greens (*dodoma*) are by far the most popular green leafy vegetables grown and consumed by over 90 per cent of the interviewed households (Table 11 and 12). Most of the families in Umuganura only grow leafy greens. Farmers in Gisanza grow a wider range of vegetables including eggplant, squash, tomato, carrot, onion, pepper and others (Table 11). Local fruit tree species include papaya, mango, avocado, guava, passion fruit, lemon, tree tomato, pineapple and watermelon. Only a small number of families in Umuganura has fruit trees in their garden (less than five per cent), whereas in Gisanza, more than a third of the households had fruit trees (Table 11).

Despite the higher number of families producing fruits and vegetables in Gisanza, however, they consumed less on average than their counterparts in Umuganura (Table 12). In this case, greater access to food markets seems to have a positive effect on diversification of household diet. Another factor such as choice of household energy and cooking fuel could also affect the household food consumption pattern. For instance, low electrification in Gisanza limits cold storage capacity at home, which in return may affect the household's consumption of easily perishable animal source foods such as meat and fish. Over 90 and 70 per cent of the families from both villages purchased sugar and cooking oil, respectively (Table 12).

Fodder

Several species of fodder grass grow well in the local environment, namely, *Pennisetum purpureum* (locally known as *urubingo*), *Tripsacum laxum/andersonii* (*tripsacum*), and *Setaria sphacelata var. splendida* (*setaria*). Farmers commonly plant *urubingo* grass on the edges of the field and the contours of steep slopes for soil erosion control (Picture 4, left). The grass is

then cut and carried to animals for feeding. With proper management of the cutting frequency and propagation, grass can grow throughout the dry season. In both villages, one can find forage grass growing on the fields even during the driest months. Farmers also cut other perennial grasses from the wayside or less well-attended neighbours' plots. *Digitaria abyssinica* (couch grass) and *Pennisetum clandestinum* (Kikuyu) are widely found (as weeds) in the region. It is often the children's daily chore to cut these grasses to feed goats and rabbits (Picture 4, right). Overall, about half of the livestock owners in Gisanza and Umuganura could not grow enough fodder grass (45 and 53 per cent) and had to resort to other sources to feed the animals. These alternative feeding practices are discussed in detail in the following sections.



Picture 4. Contour grass (left); forage (right)

Table 11. Vegetables and fruits grown in kitchen garden

Kitchen garden production	Unit	Gisanza	Umuganura
		(n ₁ =63)	(n ₂ =62)
maize	per cent*	2	n/a
beans		n/a	2
string beans		2	n/a
green vegetables		98	92
aubergine/squash		16	3
tomato/carrot		35	5
onion/hot pepper		32	2
passion fruit/tree tomato		10	2
papaya/mango		35	5
avocado/guava		24	3
pineapple/melon		8	n/a
sugar cane		n/a	2

* The cumulative exceeds one hundred because most farmers grow more than one crop.

Table 12. Household food consumption and diet compositions

Household food consumption	Unit	Gisanza	Umuganura
		(n ₁ =80)	(n ₂ =81)
Food diversity score	mean (std. dev.)	6.2 (1.6)	6.9 (1.7)
<i>(out of 12 categories)</i>			
24 hours food recall (dummy; 1 = yes)	mean (std. dev.)		
<i>maize and sorghum</i>		0.84 (0.37)	0.79 (0.41)
<i>rice and wheat (pasta, bread)</i>		0.18 (0.38)	0.53 (0.50)
<i>roots, tubers, plantains and bananas</i>		0.94 (0.24)	0.85 (0.36)
<i>vegetables</i>		0.96 (0.19)	0.96 (0.19)
<i>fruits</i>		0.19 (0.39)	0.33 (0.47)
<i>meat and poultry (n₁=78)</i>		0.03 (0.19)	0.14 (0.34)
<i>eggs</i>		0.04 (0.19)	0.06 (0.24)
<i>fish and seafood</i>		0.01 (0.11)	0.12 (0.33)
<i>pulse, legumes and nuts</i>		0.95 (0.21)	0.85 (0.36)
<i>oil and fats</i>		0.90 (0.30)	0.96 (0.19)
<i>sugar and honey</i>		0.73 (0.45)	0.77 (0.43)
<i>milk and dairy</i>		0.51 (0.50)	0.58 (0.49)

Livestock

Livestock ownership is common in Gisanza and Umuganura. Over 70 per cent of the interviewed households in both villages had at least one kind of livestock. The different types of animal found include cattle, goat, rabbit, pig, chicken and turkey. In comparison, about a quarter of the villagers did not have any livestock. Thanks to the Girinka programme, the majority of the families in Gisanza had cattle, of which most had one (61 per cent) or two cows (29 per cent). The success of the programme relies on the dairy breeds and healthy and continuous reproduction management. The 'improved' (exotic and cross) breeds make up 73 per cent of the cows (30 exotic and 43 per cent cross) and 88 per cent of the female calves (27 exotic and 61 per cent cross). In Umuganura, 39 per cent of the families rear cattle (amongst whom 28 per cent also have small stock) and 37 per cent have only small animals. Sixty-nine per cent of the cow owning families have just one cow. The one-cow production system dominates in Umuganura. Eighty-three per cent of the cows and 94 per cent of the female calves are improved dairy breeds.

Smallholder livelihood characteristics and asset-based classification

As the general context and the common forms of crop and livestock farming activities observed in the villages have been outlined we now turn to the smallholder farmers and their engagements in crop and livestock integration. Firstly, it is necessary to define and establish the general process of classifying the farmers in a way that is theoretically sound and analytically meaningful. For the household livelihood analysis, the assumption has been made that the livelihood strategies and priorities of households differ and that their characteristics are heterogeneous. In other words, the many ways in which a rural household decides how to allocate its resources to meet current and future needs are contingent upon the access to opportunities and availability of resources. This notion is similar to the entitlement approach and the sustainable rural livelihood framework where the livelihood capital and endowments are central to the welfare of households (Scoones 1998; Sen 1985). Both the ownership of assets and the relationship of people to these assets are required for one to claim the rights and access to use them to secure a particular livelihood strategy (Carter and May 1999). Similarly, it was expected to find differences in the household's reasons and objectives for pursuing specific livelihood practices such as crop-livestock farming and that these factors would vary according to the household's economic standing. This hypothesis is tested using a categorisation of families based on estimated wealth ranking.

Estimating household wealth and poverty using asset-based indicators

The conventional approach to measuring and modelling poverty is to categorise the population into economically stratified groups using a poverty line (Foster et al. 1984; Goedhart et al. 1977). However, obtaining reliable household income and expenditure data is challenging in developing countries (Montgomery et al. 2000). Despite the issues and challenges of using monetary-based indicators in poverty assessments, the preferred measures of wealth and welfare are income and consumption expenditure (Ravallion 1996). To overcome this empirical gap, an alternative approach to estimating wealth based on asset holding has gained considerable currency in the literature (Sahn and Stifel 2003). Filmer and Pritchett (2001) demonstrate a practical and reliable alternative for constructing a proxy for household economic status using the basic needs and vital assets commonly reported in Demographic and Health Surveys (including type of toilet facilities, cooking fuel, and main material of the floor and wall; and ownership of assets such as radio, telephone, bicycle). Similarly, I derive an asset index that approximates household financial standing by using the household survey data on asset ownership, housing characteristics, and household's access to local infrastructure. As most of the assets used in the analysis such as housing and land are joint household goods, it was not necessary to impute individual-level estimates of consumption or welfare (Wagstaff et al. 2007: 6). Therefore, for our research, asset index was not adjusted for household size and composition.

I use Principal Component Analysis (PCA) – a statistical technique that examines the interrelationships amongst a set of variables – to identify the underlying structure and dimensions of the household's ownership of assets and access to essential infrastructure. More precisely, the PCA technique helps in determining the appropriate weights of each asset variable with the rest of the bundle of assets that estimate the relative wealth valuation in the absence of either income or expenditure data (Montgomery et al. 2000).⁴²

A total of 14 household asset variables is included in the principal component calculation. Three are about land ownership, labour capacity and ownership of livestock. Five variables characterise the quality of dwelling materials. Four types of durable asset account for local household consumer goods and two variables indicate access to infrastructure namely energy and information (Table 13 and 15). Principal component calculations normalise each variable by its mean and standard deviation, which renders the mean value of the index to 0. Most

⁴² For more detailed technical explanation on how principal components work in the construction of an asset index, please see Filmer and Pritchett (2001) or **Appendix 7**.

asset variables take on the binary values of 0 or 1, except for the number of the economically active member variable (*hhwork*) and the size of the livestock herd (*t_tlu*). Therefore, owning a particular asset (or the absence of it) can be expressed as having an impact on the index by (f_{1i}/s_i^*) , as shown on the fourth column in Table 13 and 15. For instance, in Gisanza, a household that owns over 0.7 hectares of land (*landif2*) would have an asset index of 0.59 unit higher than those who do not. In the case of sanitation facility, a household that has an improved pit latrine (0.918) scores positively (i.e. is better off) compared to those with a traditional pit (-0.701).

Looking at the village level, having electricity at home raises the asset index by 0.987 in Gisanza as compared to 0.716 in Umuganura. In Gisanza, according to the principal component analysis, the families who have electricity at home are economically better off (by a factor of 0.987) than those who do not. In the peri-urban village, however, the energy infrastructure is less of a factor in wealth standing evaluation. Intuitively, this interpretation makes sense. The higher estimate of the weight given to the coefficient of energy infrastructure reflects the low electrification rate in Gisanza village. However, in Umuganura, since a higher number of households are on the grid, the factor of having electricity at home has lower value in explaining the household's relative wealth standing in the village.

The discrepancy in the infrastructure between the rural and more urban areas can be a cause for concern. Because urban areas have better public support and facilities than the rural areas, urban households tend to appear better-off than the rural counterparts in asset index classifications. This discrepancy has implications when making urban versus rural comparisons (Filmer and Pritchett 2001: 117, 20). To account for this bias, I do not make direct comparisons between the groups across the villages such as the poor in Gisanza versus the poor in Umuganura. To test the reliability of the asset index, ad hoc tests for internal coherence and robustness of asset-based classifications have been carried out.

Test of internal coherence

The process begins by sorting the sample populations into per centile order of the asset index value. Then, the threshold level for the lowest sub-group are established by using the most recently published poverty figures taken at the time of the survey, the Integrated Household Living Conditions Survey for Rwamagana (GoR 2011b). The report estimates that 18 per cent of the population is poor and 12 per cent extremely poor (GoR 2013e). Thus, I classify the lowest 30 per cent of the households as 'poor' for the analysis. There were no other reference values mentioned in the report to help disaggregate the non-poor population. I classify the next 40

per cent to represent the 'middle' and the top 30 per cent as the 'rich' classes to avoid small sub-sample group problems (Hair et al. 2006).

The difference in the average value of index between the poor and the rich is 3.615 and 4.745 in Gisanza and Umuganura, respectively (Table 13 and 15). The difference in asset index value between the poor and the wealthy in Gisanza is equivalent to owning the following combination of assets. Having over 0.7 hectares of land (0.590), a mobile phone (0.358) and a house with cement flooring (1.196), furnished living room suite (0.460), and electricity (0.987; Table 13). To test the internal coherence of the wealth classification index, I compare the average asset ownership of the poor, middle and rich households (see on the right-hand side of Table 13 and 15).

Table 13. Summary statistics of variables entering the computation of the asset index in Gisanza village

		Means ^a								
		weight	mean	std.dev.	Δ index		Poorest	Middle	Richest	p-value ^b
Variables	Description	(f _{1i})	(a* _i)	(s* _i)	(f _{1i} /s* _i)		(n=24)	(n=32)	(n=24)	(sig. <.05)
<i>(a) farming</i>										
landif2	own > 0.7 hectare land ^δ	0.283	0.350	0.480	0.590		0.083	0.313	0.667	0.00
hhwork	number of economically active members	0.269	2.163	1.049	0.257		1.625	2.219	2.625	0.00
t_tlu	number of livestock in tropical livestock unit ^λ	0.120	0.964	0.833	0.144		0.696	1.171	0.955	0.03
<i>(b) dwelling</i>										
fl_cement	floor material - cement, tile	0.430	0.150	0.359	1.196		0.000	0.000	0.500	ϕ
wl_mud_c	wall material - mud brick with cement plaster	0.993	0.188	0.393	2.528		0.083	0.156	0.333	0.14
wl_mud_t	wall material - timber and mud brick	-0.241	0.575	0.497	-0.485		0.833	0.594	0.292	0.00
wc_trad	pit toilet/latrine	-0.243	0.863	0.347	-0.701		0.958	0.938	0.667	0.01
wc_trad_c	pit toilet/latrine with cement floor slab	0.292	0.113	0.318	0.918		0.000	0.031	0.333	0.00
<i>(c) durable goods</i>										
radio	own radio	0.085	0.563	0.499	0.170		0.375	0.594	0.708	0.02
telep	own mobile telephone	0.172	0.650	0.480	0.358		0.417	0.688	0.833	0.00
living	own living room suite (furnished)	0.230	0.450	0.501	0.460		0.250	0.438	0.667	0.00
bike	own bicycle	0.308	0.300	0.461	0.667		0.000	0.313	0.504	0.00
<i>(d) access</i>										
elct	connected to electric grid	0.329	0.125	0.333	0.987		0.000	0.000	0.417	ϕ
inet	use internet at home	0.379	0.063	0.244	1.556		0.000	0.000	0.208	ϕ
Economic status index			0.000	1.892			-1.475	-0.498	2.140	

Note: The Bartlett's test of sphericity confirms that the correlation matrix is significantly different from the identity matrix ($\chi^2=393.831$; $df=91$; $p<0.000$). The Kaiser-Meyer-Olkin measure of sampling is adequate (0.688). Also, the Cronbach's Alpha statistic confirms that the scale coefficient is reliable (0.679). The percentage of the covariance explained by the first principal component is 26%.

α According to the EICV3 report in Rwamagana, 18% of the population were poor and 12% extremely poor (GoR 2011b). Similarly, in this study, I classify the bottom 30% of the wealth ranking households as "poorest". To keep an even size and distribution of the sub-groups, I stratified the next 40% as "middle" and the top 30% as "richest".

β The Scheffé's multiple tests compare all the means of interval-level dependent variables by all possible pairs of wealth-classified groups to determine which group means are statistically different. The Kruskal-Wallis H-test is for the non-parametric alternative to ordinal-level dependent variables. Finally, binary logistic regression tests compare the differences in means of dichotomous dependent variables.

δ I used the mean size of land cultivated per household in Rwamagana district (0.7 ha) as a reference threshold (GoR 2011b).

λ The tropical livestock unit conversion factors used are as follows: bull=1.2 cow=1.0 heifer=0.78 male calf=0.38 female calf=0.43 sheep/goat=0.2 pig=0.3 chicken/rabbit=0.04 (Jemimah Njuki et al. 2011).

ϕ The observations made are only from the richest group members. Therefore, the variable perfectly determines the outcome. No statistical model can hold under this condition.

Table 14. Breakdown of livestock ownership and herd composition in Gisanza

herd composition	description	Proportions of households owning			<i>p</i> -value ^{β} (<i>sig.</i> <.05)
		Poorest (n=24)	Middle (n=32)	Richest (n=24)	
c	cattle only	8%	38%	17%	0.46
g	goat only	0%	0%	0%	.
p	poultry only	4%	0%	0%	0.20
c + g		17%	8%	21%	0.67
c + p		8%	42%	21%	0.29
g + p		4%	0%	4%	1.00
c + g + p		13%	21%	21%	0.43
Total		54%	81%	83%	

Table 15. Summary statistics of variables entering the computation of the asset index in Umuganura village

		Means ^α								
		weight	mean	std.dev.	Δ index		Poorest	Middle	Richest	p-value ^β
Variables	Description	(f _{1i})	(a [*] _i)	(s [*] _i)	(f _{1i} /s [*] _i)		(n=27)	(n=35)	(n=27)	(sig. <.05)
<i>(a) farming</i>										
landif2	own > 0.7 hectare land ^δ	0.250	0.191	0.395	0.633		0.037	0.114	0.444	0.00
hhwork	number of economically active members	0.168	2.225	0.938	0.179		1.926	2.086	2.704	0.00
t_tlu	number of livestock in tropical livestock unit ^λ	0.127	0.820	1.177	0.108		0.573	0.817	1.071	0.17
<i>(b) dwelling</i>										
fl_cement	floor material - cement, tile	0.383	0.573	0.497	0.769		0.000	0.771	0.889	0.00
wl_mud_c	wall material - mud brick with cement plaster	0.096	0.314	0.467	0.206		0.111	0.457	0.333	0.08
wl_mud_t	wall material - timber and mud brick	-0.301	0.213	0.412	-0.731		0.593	0.086	0.000	0.00
wc_trad	pit toilet/latrine	-0.341	0.596	0.494	-0.690		0.889	0.771	0.074	0.00
wc_trad_c	pit toilet/latrine with cement floor slab	0.337	0.326	0.471	0.714		0.000	0.229	0.778	0.00
<i>(c) durable goods</i>										
radio	own radio	0.219	0.685	0.467	0.469		0.407	0.714	0.926	0.00
telep	own mobile telephone	0.261	0.843	0.366	0.713		0.556	0.943	1.000	0.00
living	own living room suite (furnished)	0.265	0.764	0.427	0.620		0.407	0.857	1.000	0.00
bike	own bicycle	0.186	0.292	0.457	0.406		0.111	0.257	0.519	0.00
<i>(d) access</i>										
elct	connected to electric grid	0.352	0.607	0.491	0.716		0.185	0.657	0.963	0.00
inet	use internet at home	0.270	0.225	0.420	0.642		0.037	0.086	0.593	0.00
Economic status index			0.000	1.977			-2.425	0.081	2.319	

Note: The Bartlett's test of sphericity confirms that the correlation matrix is significantly different from the identity matrix ($\chi^2=389.744$; $df=91$; $p<0.000$). The Kaiser-Meyer-Olkin measure of sampling is adequate (0.648). Also, the Cronbach's Alpha statistic confirms that the scale coefficient is reliable (0.714). The percentage of the covariance explained by the first principal component is 28%.

α According to the EICV3 report in Rwamagana, 18% of the population were poor and 12% extremely poor (GoR 2011b). Similarly, in this study, I classified the bottom 30% of the wealth ranking households as "poorest". To keep an even size and distribution of the sub-groups, I stratified the next 40% as "middle" and the top 30% as "richest".

β The Scheffé's multiple tests compare all the means of interval-level dependent variables by all possible pairs of wealth-classified groups to determine which group means are statistically different. The Kruskal-Wallis H-test is for the non-parametric alternative to ordinal-level dependent variables. Finally, binary logistic regression tests compare the differences in means of dichotomous dependent variables.

δ I used the mean size of land cultivated per household in Rwamagana district (0.7 ha) as a reference threshold (GoR 2011b).

λ The tropical livestock unit conversion factors used are as follow: bull=1.2 cow=1.0 heifer=0.78 male calf=0.38 female calf=0.43 sheep/goat=0.2 pig=0.3 chicken/rabbit=0.04 (Jemimah Njuki et al. 2011).

Table 16. Breakdown of livestock ownership and herd composition in Umuganura

herd composition	description	Proportion of households owning			<i>p</i> -value ^{β} (<i>sig.</i> <.05)
		Poorest (n=27)	Middle (n=35)	Richest (n=27)	
c	cattle only	7%	11%	22%	0.11
g	goat only	30%	11%	0%	0.00
p	poultry only	11%	3%	22%	0.20
c + g		11%	9%	4%	0.31
c + p		4%	9%	11%	0.31
g + p		15%	9%	4%	0.15
c + g + p		4%	17%	7%	0.65
Total		81%	69%	70%	

Table 17. Differences in classification of the poorest and richest sub-groups in Gisanza

	base case	case 1	case 2	case 3		base case	case 1	case 2	case 3
	pc analysis (all variables)	variables (b)(c)(d)	variables (b)(c)	factor analysis (all variables)		pc analysis (all variables)	variables (b)(c)(d)	variables (b)(c)	factor analysis (all variables)
Poorest	100%	79%	71%	96%	Poorest	0%	0%	8%	0%
Middle	0%	21%	25%	4%	Middle	0%	21%	21%	8%
Richest	0%	0%	4%	0%	Richest	100%	79%	71%	92%
Total	100%	100%	100%	100%	Total	100%	100%	100%	100%
r_s^*	1.000	0.792	0.646	0.938	r_s^*	1.000	0.792	0.646	0.938

* all the Spearman's rank correlation coefficients (r_s) are significant at $p < .001$ ($n = 80$)

Table 18. Cross-differences in classification of the poorest and richest sub-groups in Umuganura

	base case	case 1	case 2	case 3		base case	case 1	case 2	case 3
	pc analysis (all variables)	variables (b)(c)(d)	variables (b)(c)	factor analysis (all variables)		pc analysis (all variables)	variables (b)(c)(d)	variables (b)(c)	factor analysis (all variables)
Poorest	100%	100%	96%	96%	Poorest	0%	0%	0%	0%
Middle	0%	0%	4%	4%	Middle	0%	7%	15%	7%
Richest	0%	0%	0%	0%	Richest	100%	93%	85%	93%
Total	100%	100%	100%	100%	Total	100%	100%	100%	100%
r_s^*	1.000	0.963	0.907	0.944	r_s^*	1.000	0.963	0.907	0.944

* all the Spearman's rank correlation coefficients (r_s) are significant at $p < .001$ ($n = 89$)

All asset holdings across the wealth groups in Gisanza are significantly different (p -value $<.05$) except for one variable (wl_mud_c ; Table 13). Similarly, the differences in all asset ownership are significant in Umuganura (p -value $<.001$) except for the wall material (wl_mud_c) and the number of livestock in tropical livestock units (t_tlu ; Table 15). Differences in the quality of housing material between the poor and the rich correspond with the field observations (Picture 5). The same is true for the ownership of productive assets. For example, in Gisanza, while the majority of the rich own more than 0.7 hectares of land, compared to only eight per cent of the poor households (Table 13). For the variables concerning cemented wall and total livestock size (wl_mud_c and t_tlu), the differences are not so evident than the rest of the asset holdings, and they need further explanation.



Picture 5. Cement wall (left); cemented mudbrick wall (right)

First, the particularity with the wall material variable (wl_mud_c) is due to the widespread local building technique in the area. Plastering the outside wall with a thin coat of cement helps mask the poorer quality base material (mudbrick) and is much more affordable than building a wall with fired bricks or cement blocks. Second, I use the Tropical Livestock Unit (TLU) to express the total amount of livestock holding irrespective of the composition of species of different average sizes. Deriving a common unit that is based on the ratios of body and metabolic weights is useful at this stage of the analysis because it condenses the number of livestock variables into a single variable without much loss of information.⁴³ The unitary standard of TLU is one cattle with a body weight of 250 kilogrammes (FAO 2011d). However, the exchange ratios for animals with different body weights vary across countries and continents and production systems (Jemimah Njuki et al. 2011). Moreover, “strictly speaking,

⁴³ Metabolic Weight = (Body Weight)^{0.75}

they can only be compared in this way when the different species are under the same feeding system, something that is often not the case” (Jemimah Njuki et al. 2011: 11). For the wealth valuation, however, TLU provides an acceptable estimate of the aggregate size of the herd. I use the TLU conversion equivalents representative for sub-Saharan African livestock (Jemimah Njuki et al. 2011: 12-3).⁴⁴

In Gisanza, the differences in TLU between the wealth groups are statistically significant ($p < .05$; Table 13), whereas in Umuganura they are not ($p = 0.17$; Table 15). I break down the TLU into livestock types and herd composition characteristics to further gain the insights from this observation (Table 14 and 16). Both in Gisanza and Umuganura, over 90 per cent of the herd composition comprises of three dominant species of cattle, goat, and poultry (aggregate data not presented). In Gisanza, the majority of the farmers keep more than one species (see c+g, c+p, g+p, c+p+g; Table 14). In contrast, farmers concentrate more on single species management in Umuganura (see c, g, p; Table 16). The recent livestock transfer from the Girinka programme explains in part the widespread presence of cattle across the sample population in Gisanza (Table 14). Nearly half of the poor in Gisanza have a cow. In Umuganura, the poor mainly keep small livestock (see g, p, g+p; Table 16). Although the proportions of households with different herd composition are statistically indifferent, the overall patterns that emerge from the analysis closely match the general assumption. In both villages, the less-wealthy families own fewer cattle than their non-poor neighbours.

Test of robustness

Three additional asset indices with different bundles of asset variables to test if the asset-based wealth rankings yield consistent classifications are reproduced (Filmer and Pritchett 2001: 118-9). In the first variant case, the farming related variables are excluded and in the second test, only the household-specific variables using housing material and durable goods are used. I then deploy factor analysis which is a close but methodologically different alternative of calculating and deriving the asset index weights (Table 17 and 18). The rationale for excluding the land and labour related variables in the first case is to see how the household’s farming capacity contributes to the overall household’s wealth standing. Additionally, the second model excludes the infrastructure variables (such as access to electricity and information) to counter for the urban/rural related bias. The table on the left-

⁴⁴ Cattle (bull) = 1.2 TLU, Cattle (cow) = 1.0, Cattle (heifer) = 0.78, Cattle (male calf) = 0.38, Cattle (female calf) = 0.43, Goat = 0.20, Poultry/rabbit = 0.04, Pig = 0.30

hand side holds the poorest as the reference group, whereas the right-hand side compares the households belonging to the wealthiest group.

Nearly all the households identified as poor and rich in the base case also belong to the same category in the variant cases (Table 17 and 18). There is a minor overlap in the second model in Gisanza, where four per cent of the poor households find themselves in the rich category after removing the community infrastructure factor (see Table 17). The wealth clusters are consistent all across the variant cases in Umuganura. None of the poor households belong to the wealthy group, and vice versa (Table 18).

Moreover, I assess the statistical dependence between the rankings of the cases using the Spearman rank correlation coefficient (r_s).⁴⁵ The Spearman correlations measure the strength of association between the base and the variant cases in producing the same ranking of households (Filmer and Pritchett 2001: 118-9). The correlations between the two variables range between ± 1 . When the observed ranks between the two are similar, it approaches to positive 1, and to negative 1 if dissimilar (Healey 2014: 354). All the Spearman's rho values are statistically significant ($p < .001$) and show strong positive relationships between the asset index classifications (max. $r_s = 0.963$ for case 1 in Umuganura and min. $r_s = 0.646$ for case 2 in Gisanza; see Table 17 and 18).

The results of the coherence and robustness tests of the asset indices confirm that the wealth ranking classification of the sub-population is empirically reliable for the subsequent analysis. Before turning our focus to the various patterns of crop and livestock integration practices, I briefly present the farm-related characteristics and productive asset ownership of the poor, middle and rich households.

General farming characteristics and agricultural asset ownership

The families in Gisanza and Umuganura have distinctive patterns of agricultural asset ownerships that vary across the wealth groups (Table 19 and 20). The landholding data in Gisanza show that the poor have on average the least amount of arable land (0.21 hectare), whereas the middle and the rich cultivate as much as three to six times more than the poor (see Table 19). Similarly, the poor have a significantly smaller size of family compared to the other groups. In a smallholder farming context, family members are the primary source of labour, and thus, lower family size can be a drawback. The discrepancy in the proportions of the family members working in farming and other economic activities demonstrates a case in

⁴⁵ The conventional unit ρ (rho) is for any population and r_s is the symbol for any sample population. (Healey, 2014: 359).

point. First, the majority of household members work in agriculture regardless of the household's classification (p -value=0.13; see Table 19). While family farming employs most of the middle and the wealthy households' labour (93 and 83 per cent, respectively), the poor devoted fewer family members to the task (76 per cent). The poor also work in other casual labour jobs to supplement their livelihood (24 per cent).⁴⁶

In Umuganura, there is an apparent gender disparity between the heads of households belonging to different wealth groups (Table 20). That is, there are proportionally more female headed-households in the poor sub-group than the middle and the rich (44 versus 26 and 19 per cent, respectively). The implications of gender imperatives in agriculture-based livelihoods is explored in the next chapter. Households in Umuganura have greater access to formal, salaried jobs than Gisanza due in part to its proximity to Rwamagana town and the markets.⁴⁷ However, the job opportunities are not evenly taken up across the groups. For instance, there are significantly more families in the non-poor clusters whose members work in non-farming jobs than the poor group (22 and 39 versus 11 per cent). The opposite trend is true for households relying on farming as the primary economic activity. The poor depend more on agriculture than the other groups (76 versus 60 and 41 per cent, respectively). While agriculture may seem to be the central preoccupation of the poor, we should not overlook the fact that over 40 to 60 per cent of the better-off families and their head of households engage in farming. How these different groups approach and practice agriculture is the primary focus of the analysis in the next chapter. However, regardless of the wealth standing, the average sizes of land are small in Umuganura. Even amongst the wealthiest families, their average landholding is less than the district average of 0.7 hectares (Table 20). In a peri-urban setting where land is premium, a livelihood solely based on agriculture would likely be insufficient to provide for the entire family.

⁴⁶ Casual labour work includes working in another farm or construction sites as a day labourer.

⁴⁷ Formal wage and salaried work include work in the manufacturing and service sectors (such as in hotels and restaurants, or transportation), trades (such as mason or teacher) and owning a small business.

Table 19. Agricultural assets and family characteristics in Gisanza

farming characteristic	unit	Poorest (n=24)	Middle (n=32)	Richest (n=24)	p-value^β (sig. <.05)
Family					
average family size	person	3.6	5.3	5.9	0.02
female headed household (hh)	per cent	50%	28%	33%	0.23
main occupation of hh					
<i>farming</i>	per cent	71%	94%	96%	0.01
<i>non-farming</i>		0%	3%	4%	0.34
<i>casual labouring</i>		21%	3%	0%	0.00
Proportion of family members					
<i>farming</i>	per cent	76%	93%	83%	0.13
<i>non-farming</i>		0%	2%	9%	0.01
<i>casual labouring</i>		24%	6%	8%	0.22
Land					
average land holding	hectare	0.21	0.67	1.24	0.00
average number of plots	plot	2.5	2.9	3.0	0.46

β The Scheffé's multiple tests compare all the means of interval-level dependent variables by all possible pairs of wealth-classified groups to determine which group means are statistically different. Pearson's *r* correlation coefficient assesses the strength and direction of relationships of binary variables. Alternatively, binary logistic regression tests also compare the differences in means of dichotomous dependent variables.

Table 20. Agricultural assets and family characteristics in Umuganura

farming characteristic	unit	Poorest (n=27)	Middle (n=35)	Richest (n=27)	p-value^β (sig. <.05)
Family					
average family size	person	5.3	5.2	6.8	0.01
female headed household (hh)	per cent	44%	26%	19%	0.03
main occupation of hh					
<i>farming</i>	per cent	70%	57%	48%	0.10
<i>non-farming</i>		0%	34%	44%	0.00
<i>casual labouring</i>		11%	0%	4%	0.18
Proportion of family members					
<i>farming</i>	per cent	76%	60%	41%	0.00
<i>non-farming</i>		11%	22%	39%	0.00
<i>casual labouring</i>		6%	13%	17%	0.12
Land					
average land holding	hectare	0.22	0.43	0.66	0.16
average number of plots	plot	1.4	2.1	2.2	0.04

β The Scheffé's multiple tests compare all the means of interval-level dependent variables by all possible pairs of wealth-classified groups to determine which group means are statistically different. Pearson's *r* correlation coefficient assesses the strength and direction of relationships of binary variables. Alternatively, binary logistic regression tests also compare the differences in means of dichotomous dependent variables.

Patterns of crop and livestock integration

In chapter 2, five characteristics of mixed crop-livestock farming were introduced, where resources from one production activity flow and are recycled into another. For this study, there are three parameters that can be used to analyse the extent and the patterns of crop and livestock integration. The first is the use and importance of animal excreta. How do farmers fertilise the soil and how do they perceive the role of livestock manure in soil fertility management? Do farmers use manure or other fertilisers? The second is the sourcing of animal feed and the use and importance of crop residue as feed. Do farmers have enough grass to feed their animal, and if not, how did they manage the discrepancy? Do farmers purchase feed supplements, recycle crop residues, or forage tree fodder? The third element of integration is about the role of animals as functional livelihood assets. For what other purposes do families keep different types of animals? This question is relevant as the extent of integration and resource exchange in farms depends on the alternative livelihood functions of the livestock. While some roles may complement crop farming practices, others may lead to non-integrated strategies such as specialisation into monocropping or dairy farming. The high inclination to specialise in dairy production in both villages is an indication of this trend.

Importance of animal excreta

Over 70 per cent of the families in Gisanza assessed that they needed additional soil nutrients and inputs on their land (aggregate data not presented).⁴⁸ The district office recommends the use of chemical fertiliser, but only one in four households reported using it in the year preceding the survey (Table 21). On average, the poor and middle groups of farmers applied less than 31 kilogrammes of fertilisers last year.⁴⁹ As a point of reference, the recommended rates of fertilisers for maize is 41 kg of nitrogen (N) and 46 kg of phosphorous pentoxide (P₂O₅) per hectare. For bean and soybean it is 18 kg N and 46 kg P₂O₅/ha and 50 kg/ha of DAP for cassava (Cyamweshi et al. 2017).

In Gisanza, all farmers use animal excrement as fertiliser. People from all wealth categories use cattle manure (Table 21). Collecting manure from animals such as goats is more difficult because of lack of permanent housing and semi-grazing. Despite the difficulty with using goat's dung, however, the majority of goat owners manage to collect some of the manure by

⁴⁸ The differences in their perception varied little across the groups (Pearson $\chi^2 = 2.992$; p -value = 0.559).

⁴⁹ Most of the farmers use fertiliser sparingly by using a spot application technique. Therefore, the total figure of fertiliser applied per hectare (kilogrammes/hectare) can be misleading. The most commonly found local fertilisers are Diammonium phosphate (DAP), urea and NPK fertilisers.

tethering overnight in the house compound. Chicken manure is even harder to obtain because most of the chicken usually roam freely. Adding to this challenge, the amount of chicken manure is minimal in organic matter. Building a chicken coop would solve most of the manure collection problems, but farmers are reluctant to invest in intensive poultry production because of a variety of economic reasons related to its holding costs. These issues are discussed in the following chapter. While the efforts to collect chicken manure may not seem worthwhile, the nutrient contents of manure from poultry are higher than the ruminants' (Barker et al. 2002). What is also interesting is that the poor are more likely to use chicken manure than the rest (71 versus 42 and 20 per cent, respectively), which reflects the differential opportunity costs of collecting and using chicken manure between the rich and the poor.

Table 21. Soil fertility management in Gisanza

soil fertility management	unit	Poorest (n=24)	Middle (n=32)	Richest (n=24)	p-value^β (sig. <.05)
use chemical fertiliser	% of households	22%	28%	25%	0.80
average amount (n=20)	kg per year	26	31	89	0.27
use organic manure from					
cow (n=53)	% of households	100%	100%	100%	1.00
goat (n=26)		75%	86%	64%	0.53
chicken (n=29)		71%	42%	20%	0.03
enough manure year-around	% of households	17%	56%	58%	0.00
if not enough (n=43)					
purchase	% of households	5%	14%	50%	0.00
nothing		68%	21%	10%	0.00

β The Scheffé's multiple tests compare all the means of interval-level dependent variables by all possible pairs of wealth-classified groups to determine which group means are statistically different. Pearson's *r* correlation coefficient assesses the strength and direction of relationships of binary variables. Alternatively, binary logistic regression tests also compare the differences in means of dichotomous dependent variables.

In Umuganura, around 60 per cent of the farmers expressed the need for additional soil inputs (aggregate data not shown). However, the perceived needs of the poor, middle and rich are very similar, and their differences are not significant (p -value=0.213, aggregate data not shown). A small number of families use chemical fertiliser, and the reported amounts are small (Table 22). Interestingly, the poor used more chemical fertiliser than the rich, which seems to indicate the higher importance and relevance of investment in farming for the poor. However, the small number of observations limits arriving at robust conclusions. While over half of the farmers claim to have enough organic manure (52 per cent of the poor, 50 per cent of the middle, and 57 per cent of the rich), the others purchase organic fertiliser from neighbours to fill the gap (18, 13, and 50 per cent respectively; Table 22). However, many poor and middle

group farmers could not afford to purchase manure (27 and 38 per cent, respectively; Table 22). Cattle manure is the principal source of organic fertiliser for the wealthier farmers. Interestingly, farmers from the poorest groups said to use goat manure as much as cattle manure (69 versus 67 per cent, respectively). This observation may seem contradictory at first. Given the lack of organic manure production amongst the poor, why would they not maximise their cattle manure production? One of the reasons has to do with the poor design of cow sheds and the lack of space for manure storage. Transporting bulky manure is another hurdle.

Table 22. Soil fertility management in Umuganura

soil fertility management	unit	Poorest (n=27)	Middle (n=35)	Richest (n=27)	p-value^β (sig. <.05)
use chemical fertiliser	% of households	17%	14%	13%	0.68
<i>average amount</i> (n=11)	kg per year	25	32	15	0.73
use organic manure from					
cow (n=33)	% of households	67%	88%	82%	0.56
goat (n=36)		69%	50%	25%	0.09
chicken (n=34)		30%	15%	18%	0.51
enough manure year-around	% of households	52%	50%	57%	0.77
if not enough (n=37)					
<i>purchase</i>	% of households	18%	13%	50%	0.09
<i>nothing</i>		27%	38%	0%	0.19

β The Scheffé's multiple tests compare all the means of interval-level dependent variables by all possible pairs of wealth-classified groups to determine which group means are statistically different. Pearson's *r* correlation coefficient assesses the strength and direction of relationships of binary variables. Alternatively, binary logistic regression tests also compare the differences in means of dichotomous dependent variables.

In sum, from the soil fertility management standpoint, the differences between the poor, middle and rich groups of farmers are insignificant. The rates of chemical fertiliser application are low for peri-urban farmers. From the survey data alone, however, it is difficult to discern the exact reasons for the lower rates of fertiliser application in Umuganura. There are two possible reasons. The first is an obvious one: the use of inputs vary in proportion to the size of land and number of livestock. However, this idea does not entirely explain the low application of chemical fertiliser amongst the rich who have more sizeable land. This leads to the second explanation (although speculative at this stage of analysis): the farmers in Umuganura are not actively pursuing agricultural integration and intensification of production. This reasoning challenges the initial assumption that given the infrastructure and services that are conducive to intensification, some farmers would find means and ways to “stepping up” through more intensive farming activities. To answer this question more satisfactorily, I move on to the second parameter of analysis, which is animal feed management and the importance of crop residue feeding.

Sourcing of animal feed and the importance of crop residue feeding

Forage grass is the first choice of animal feed in both villages. Farmers in Gisanza grow *Urubingo*, *Tripsacum* and *Setaria* on the boundaries of the land throughout the year, but the majority of the farmers, regardless of their classifications, could not feed their animals with grass alone (Table 23). Two factors restrict the expansion and intensification of grass production in Gisanza. Firstly, because farmers continually crop their land, there is little space left for grass production. This competition is one of the reasons why nearly all smallholders adopt contour grass strips. Secondly, farmers do not irrigate, and therefore, both crop and grass cultivations are subject to natural cycles of precipitation. The lack of water in return severely affects grass production during the dry season. To make up the difference in grass production, farmers either buy fodder grass from neighbours or forage from surrounding areas. *Urubingo*, *Tripsacum* and *Setaria* are purchased mainly for cows, whereas couch grass and *Kikuyu* are usually for small ruminants.

Clear distinctions appear in the feeding strategies adopted by the poor and the rich. While all the wealthy farmers could afford to purchase grass, only half of the poor do so (Table 23). When it comes to gathering grass on the wayside, the opposite trend happens. None of the prosperous farmers gathers weed grass from public spaces, but over 75 per cent of the poor and the middle families do so (Table 23). There is no formal market for buying and selling grass in Rwamagana. Prices vary individually and according to the quality and volume, but also depend on the seasonal demand and supply. Moreover, a sizeable and regular buyer may even have some influence on the price negotiation. For example, one of the key informants from Kigabiro-MCC regularly buys grass, and he pays 20,000 RWF for the grass grown on a 50 metres square plot (i.e. five by ten metres). With this amount of grass, he manages to feed two dairy cows for two to three weeks (Kigabiro-MCC member, personal communication, 19 March 2015). Such a significant and recurrent payment of cash is usually beyond the reach of many low-income families, except during the lactation period when sales revenue from milk can offset the costs.

Table 23. Animal feed management in Gisanza

feeding management	Unit	Poorest (n=24)	Middle (n=32)	Richest (n=24)	p-value^β (sig. <.05)
enough fodder grass	% of households	33%	37%	50%	0.24
if not enough (n=26)					
<i>purchase</i>	% of households	50%	43%	100%	0.03
<i>foraging</i>		75%	79%	0%	0.00
feed supplements					
<i>maize/rice bran</i>	% of households	13%	28%	33%	0.09
<i>mineral block</i>		62%	81%	85%	0.13
paying for water					
<i>public tap</i>		25%	25%	50%	0.06
alternative feed (n=59)					
<i>banana leaves/stem</i>	% of households	46%	69%	50%	0.99
<i>maize/sorghum leaves</i>		77%	100%	90%	0.31
<i>weed/wild grass</i>		92%	88%	80%	0.28
<i>leftover food</i>		31%	38%	50%	0.26

^β Pearson's *r* correlation coefficient assesses the strength and direction of relationships of binary variables. Alternatively, binary logistic regression tests also compare the differences in means of dichotomous dependent variables.

However, milk production yield is commensurate with the quantity and quality of feed and drinking water. Therefore, in addition to grass, energy dense supplements such as maize and rice bran are highly recommended for lactating cows. A 100-kilogramme sack of maize or rice bran sells at 8,000 RWF. Again, not everyone prioritises dairy production or can afford the cost of supplements. About one in three families in the wealthier groups use maize and rice bran in comparison to only 13 per cent of the poor households (Table 23). Similarly, most of the farmers with cattle source drinking water from a public tap. Typically, villagers pay about 10 RWF for 20 litres of water plus the bicycle delivery charge of 100 RWF (personal communication with leading village official, 20 March 2015). Depending on the milk productivity and yield, farmers give cows 20 to 40 litres of water per day (district veterinarian, personal communication, 17 March 2015).

Animals also feed on crop residues. Dry stalks and leaves from cereal crops such as maize and sorghum are high in demand (Table 23). However, these fibrous by-products are not easily digestible and contain low levels of nitrogen, protein and minerals (Preston and Murgueitio 1992: 69). Nevertheless, farmers use the leaves without balancing the nutrients nor use chemical treatment to improve palatability. Another local staple are plantains and bananas. Their pseudo-stems and leaves provide a bulk of biomass and water. However, similar to cereal crops, the nutrient values are low (Kimambo and Muya 1991). Most of the poor and middle

group farmers rely on post-harvest by-products that are of limited nutritional value, and have no means to purchase additional grass or energy-dense commercial feed.

Table 24. Animal feed management in Umuganura

feeding management	unit	Poorest (n=27)	Middle (n=35)	Richest (n=27)	p-value^β (sig. <.05)
enough fodder grass year-around if not enough (n=32)	% of households	33%	37%	19%	0.24
<i>purchase</i>	% of households	25%	60%	80%	0.01
<i>foraging</i>		75%	50%	20%	0.01
feed supplements					
<i>maize/rice bran</i>	% of households	0%	23%	26%	0.01
<i>mineral block</i>		23%	46%	47%	0.10
paying for water					
<i>public tap</i>		63%	29%	11%	0.00
<i>house tap</i>		4%	40%	48%	0.00
alternative feed (n=65)					
<i>banana leaves/stem</i>	% of households	55%	58%	41%	0.59
<i>maize/sorghum leaves</i>		45%	42%	41%	0.78
<i>weed/wild grass</i>		59%	77%	59%	0.92
<i>leftover food</i>		32%	8%	12%	0.07

β Pearson's *r* correlation coefficient assesses the strength and direction of relationships of binary variables. Alternatively, binary logistic regression tests also compare the differences in means of dichotomous dependent variables.

The differences in feeding management practices contrast between the wealth groups in Umuganura. Only one-third of the low-income families manage to produce enough grass (Table 24). In comparison, just 19 per cent of the wealthy families achieved self-sufficiency. However, more economically-able families overcome the deficit by purchasing grass from neighbours (60 to 80 per cent, respectively), whereas the less well-off turn to foraging and gathering (75 per cent, Table 24). Similarly, none of the poor farmers buy commercial feed. About a quarter of the non-poor households purchase and use maize and rice bran (Table 24). As for drinking water, the poor rely mostly on a public tap (63 per cent). Poor farmers pay for the water, but also, they spend more time (for queuing and waiting during peak hours) and energy for transporting water, all of which raise the cost of feeding the cow. In contrast, the non-poor families have their water tap in the compound which saves them the trouble of sourcing water from outside (40 per cent of the middle group and 48 per cent of the rich; Table 24). Farmers also feed crop residues to their animals but less so than the farmers in Gisanza (see Table 23 and 24). The main reason is once again related to the size of the land and crop choices. That is, the amount of post-harvest residues is proportionate to the crop

density and the surface area. Nevertheless, for over 45 per cent of the poor farmers, crop residues are an essential part of the feeding regime.

The distinctive feature of purchasing and gathering strategies amongst the poor and the rich arises from two conditions. The first results from the family's purchasing power. Poor farmers have little disposable income and economic security to invest in feed. Poor farmers are well aware of the potential profit from milk sales, but the profit margin of the milk production (most of them keep only one cow) is minimal after deducting feed and labour costs. In other words, the financial risk of intensive dairy production is much higher for the poor farmers. The second condition arises from local feeding practices that are specific to the type of livestock. Farmers only feed purchased grass to cows and not to small ruminants. This reflects the economic rationale that at the moment, dairy production is the only financially viable investment worthy of an intensive feeding regime. Although goats are actively traded in the local markets, farmers do not rear them intensively. The question of why farmers do not consider commercially-oriented goat production leads us to the importance of identifying and recognising the multiple livelihood functionalities of livestock as a productive asset.

Multi-functionality and asset attributes of livestock

There is ample evidence in the literature that households with different levels of income keep livestock for the range of benefits and services these animals provide (Pica-Ciamarra et al. 2011). In chapter 2, I elaborated on the role of livestock in the rural livelihoods using an asset functions framework and their differential attributes (Dorward et al. 2001). Nine asset attributes are relevant to our analysis: life, productivity, utility, security, holding costs, convertibility, complementarity, ownership and control, and lastly, social relations (Table 3). In the following section, I focus on utility and convertibility aspects of livestock functions.

Cattle

Milk production ranks as one of the top priority functions and utilities for cattle owners in Gisanza with the other being manure as shown earlier in Table 21 (Table 25). Farmers typically keep about 30 per cent of their production for home consumption, sell about 60 per cent, and share the remaining milk with neighbours and families (Table 26). The average milk production level of the poor is almost equal to the middle-group farmers' production (6.8 versus 6.9 litres, respectively). No one rears cattle for meat or fattening (Table 25). Interestingly, there are significantly more low-income families who prioritise growing the herd size (reproduction) than the rest of the groups (27 versus 12 and 0 per cent, respectively). This characteristic may

be due to the *Girinka* programme. Keeping in mind that some thirty families received *Girinka* cows about a year before the survey, the first-generation beneficiaries are expected to pass on the offspring to the next awaiting recipients. While I did not identify programme beneficiaries in this study, in theory, they are most likely to be found amongst the poor and possibly in the middle group. The fact that none of the wealthiest families prioritises reproduction also suggest that this group may have already reached their optimal herd size. This point is returned to in the next chapter where I corroborate with the findings from the qualitative analysis. Moreover, cattle play a much less significant role as savings (through cashing in offspring) for the poor than for the rich (27 versus 82 per cent, respectively; Table 25). This finding corresponds with the above logic that if families have achieved the desired number of cattle, then they are more likely to sell the offspring for cash. Many of the poor smallholders, however, are still in the process of growing their herd, and thus, do not want to sell their animals yet. This reason applies especially to the *Girinka* beneficiaries as they are not allowed to sell any offspring until they fulfil the promise to pass on.

In Umuganura, dairy production is the top activity of cattle owners (Table 27). None of the farmers pursues beef production, and therefore, farmers sell male calves early on. Looking at the reproduction and savings utilities, farmers from the poor class seem to equally balance the needs of growing the herd and cashing in their investment. While this is not a definitive assessment of livestock reproduction management, there are compelling economic and agronomic reasons why the majority of farmers keep only one cow. The physical constraint to enhanced dairy production is the lack of land to grow fodder grass. Farmers in the peri-urban village have less access to arable land and rely on purchased feed from outside their farm to make up for the shortage of grass. The high cost of commercial feed is yet another and the main financial barrier to the economically deprived as shown in Table 24. In comparison, only 45 per cent of the better-off families reportedly keep cows as a savings account (Table 27). In the case of peri-urban settings, a cow's utility as savings is less appealing for the rich because they have access to financial institutions and commercial banks.⁵⁰

While milk production ranks high for all cattle owners, the differences in average milk production levels between the families are striking (Table 28). The lower sub-groups of families only manage to get 1.6 litres of milk per day, of which half of the milk goes to the market and

⁵⁰ While I did not include financial account holding questions in the survey, I was however, able to ascertain this fact from speaking to farmers at the Kigabiro-MCC and also during in-depth life stories interviews in Umuganura village (April-May 2015).

the other half to the family members. Considering the average size of a typical poor household of five people (as shown in Table 20), the milk consumption rate would be less than a cup per person. Similarly, the financial contribution of selling less than a litre of milk is also questionable. These points will be revisited in more detail through the life stories and experiences of those retain their one-cow production in next chapter.

Table 25. Livelihood functions and attributes of livestock in Gisanza

livestock functions	unit	Poorest (n=24)	Middle (n=32)	Richest (n=24)	p-value^β (sig. <.05)
cow (n=53)					
<i>milk</i>	% of households	90%	100%	100%	0.14
<i>meat</i>		0%	0%	0%	-
<i>reproduction</i>		27%	12%	0%	0.02
<i>savings</i>		27%	48%	82%	0.00
goat (n=26)					
<i>meat</i>		0%	0%	0%	-
<i>reproduction</i>		50%	29%	27%	0.32
<i>savings</i>		75%	100%	82%	0.77
chicken (n=29)					
<i>egg</i>		100%	100%	80%	0.13
<i>meat</i>		0%	33%	20%	0.40
<i>reproduction</i>		71%	67%	40%	0.16
<i>savings</i>		71%	67%	70%	0.97

β Pearson's *r* correlation coefficient assesses the strength and direction of relationships of binary variables. Alternatively, binary logistic regression tests also compare the differences in means of dichotomous dependent variables.

Table 26. Milk production and consumption in Gisanza

utility	unit	Poorest (n=5)	Middle (n=18)	Richest (n=13)	p-value^β (sig. <.05)
milk					
total	litre (std.dev.)	6.8 (4.1)	6.9 (4.2)	10.2 (6.5)	0.19
home		2.0	2.3	3.2	0.24
market		4.2	4.6	6.4	0.50
give & share		0.6	0.1	0.5	0.50

β The Scheffé's multiple tests compare all the means of interval-level dependent variables by all possible pairs of wealth-classified groups to determine which groups means are statistically different.

Table 27. Livelihood functions and attributes of livestock in Umuganura

livestock functions	unit	Poorest (n=27)	Middle (n=35)	Richest (n=27)	p-value^β (sig. <.05)
cow (n=33)					
<i>milk</i>	% of households	100%	94%	100%	0.83
<i>meat</i>		0%	0%	0%	-
<i>reproduction</i>		33%	25%	9%	0.21
<i>savings</i>		33%	50%	45%	0.72
goat (n=36)					
<i>meat</i>		0%	6%	0%	0.62
<i>reproduction</i>		56%	31%	25%	0.12
<i>savings</i>		63%	81%	100%	0.07
chicken (n=34)					
<i>egg</i>		50%	92%	82%	0.09
<i>meat</i>		20%	38%	36%	0.43
<i>reproduction</i>		30%	23%	27%	0.90
<i>savings</i>		60%	46%	45%	0.51

β Binary logistic regression tests compare the differences in means of dichotomous dependent variables.

Table 28. Milk production and consumption in Umuganura

utility	unit	Poorest (n=4)	Middle (n=8)	Richest (n=10)	p-value^β (sig. <.05)
milk					
total	litre (std.dev.)	1.6 (0.9)	6.9 (3.1)	8.4 (5.2)	0.03
home		0.8	2.4	3.9	0.01
market		0.8	4.1	4.1	0.23
give & share		0.0	0.4	0.4	0.69

β The Scheffé's multiple tests compare all the means of interval-level dependent variables by all possible pairs of wealth-classified groups to determine which group means are statistically different.

Small livestock

Chicken and goats are an integral part of smallholder livelihoods in the villages in Rwamagana. A majority of the farmers, regardless of their economic status, said they kept goats for savings purposes (Table 25). Farmers also kept chickens as savings (71 per cent of the poor, 60 per cent of the middle and 70 per cent of the rich), but a goat fetches over five to ten times more money than a chicken in the local market. Therefore, farmers would keep and sell goats for medium to large cash expenses such as children's annual school fees and medical emergencies. None of the families rear goats for meat.

Chicken is useful for small cash needs, but its high *convertibility* is also its Achilles heel. Farmers tend to sell chicken more frequently, and the flock continually depletes and rarely builds up. Thus, the majority of the chicken owners, regardless of the wealth classification, prioritise reproduction (Table 25). Chickens also contribute to the household's nutrition. Nearly all the chicken owning families consume eggs, and even meat for some non-poor homes (33 per cent of the middle and 20 per cent of the rich).

In Umuganura the primary *utility* function of goats and chickens is for savings (Table 27). There is an active trade in small livestock in the nearby Rwamagana town and the easy access to the market enhances even more, their *convertibility* attribute. Once again, chicken is essential for the family's nutrition and diet, as it provides eggs and occasionally meat for consumption. However, the *utility* of having chicken as animal-based protein foods appears less critical for the poor than the non-poor families (but the differences are not statistically significant; Table 27). It is probable that poorer households have less disposable cash than others and therefore would prioritise cash sales than home consumption.

Conclusion

In this chapter, I assessed two central components of crop-livestock integration: the use of animal manure in soil fertility management and the sourcing of animal feed through grass production and of crop residues. The extent of integration of crop and livestock production varied across the study sites and wealth categories.

Organic manure is the most significant soil input for farmers in Gisanza. Manure production (especially from cattle) is, therefore, an inseparable component of soil fertility and livestock management. The capacity to rear cattle is contingent upon each household's resources and productivity. Many farmers, regardless of their financial standing, faced difficulties in sourcing

sufficient manure. However, how they deal with the shortage differentiated the poor from the non-poor farmers. While those who can afford it purchase manure from neighbours; the poor, however, relied on manure from small livestock, which is available in smaller quantities and more laborious to collect and apply. Thanks to the recent transfer of *Girinka* cows in Gisanza, more poor farmers are entering dairy production and producing manure.

In contrast, farmers in Umuganura cultivate on much smaller land to meet the household consumption demands. Despite having good access to markets and services, the economic viability of crop farming is low due to the limited availability of arable land. Livestock owners fertilise their crops with manure, but dairy production is their primary preoccupation. The rich, and to some extent the middle group families, rely on off-farm employment, which reduced their economic dependence on agriculture. The poor, on the other hand, have fewer resources with which to diversifying livelihood and are less able to step out of farming. Given the extremely unfavourable farming conditions of the poor households in this peri-urban setting, they have difficulty meeting their household food demands.

Most of the livestock farmers in the two sites are unable to meet their own need for forage grass. The shortage of fresh grass during the dry season often negatively influences dairy production. The best locally available solution is to purchase grass from other farms and supplement the diet with energy-dense cereal brans. These solutions are costly, however, and their price range is beyond the financial means of many farmers. The wealthier families had recourse to commercial feed, which allows them to maintain or increase the level of production. Moreover, although other technical solutions such as silage making are locally known, they are impractical because of the lack of surplus grass and storage space. Economically-less endowed families can only afford to feed their animals with less nutritious feedstuff such as couch grass, *Kikuyu* and crop residues. As the resulting low dairy yields of the poorer households in Umuganura indicate, achieving commercial viability from intensive dairy production seems a long way away for these smallholders.

In sum, I found a substantial basis for crop and livestock integration through soil fertility and animal feed management in Rwamagana. The extent of integration and its implications to other livelihood functions impacted differently to different groups of farmers. However, the evidence of stepping up through mixed crop-livestock farming is weak even for the farmers who are in better economic position (in Gisanza) and who live in areas with better infrastructure and market advantages (in Umuganura). I also argue for a more nuanced understanding of smallholders' integration strategy by looking at multiple functionalities and

livelihood utilities that livestock represents for different farmers. For instance, while integration of farming and dairy production presented a viable economic opportunity to some, a similar set of conditions posed a great deal of risk to the economically vulnerable households. The findings from the household survey assessments indicate that the observed patterns of crop and livestock production and their associated livelihood pathways differ between the economically-stratified sub-groups of farmers.

This leads us next to consider a final set of research questions as follows; what are the underlying trajectories that led to the observed patterns of engagement with crop and livestock production? For whom, and in what circumstances is intensification through crop and livestock integration a potential pathway out of poverty? What does the experience of promoting crop-livestock integration tell us about livestock asset transfer programmes and livestock-in-kind development strategies?

Chapter 7. Pathways of livestock-based development

Chapter summary

This chapter is about the underlying factors that differentiate the propensities for crop-livestock integration by smallholders in Rwanda. Livestock and its role in the development of rural livelihoods is the focus of the analysis. Through life history interviews, with an emphasis on engagement with livestock keeping and related life events, the chapter explores accounts of livestock-based asset accumulation amongst different groups of farmers. The main argument of this chapter is that pathways of agricultural intensification and crop-livestock integration are highly contingent on agro-ecological and socio-economic conditions. They are also shaped and affected by the multiplicity of functions and characteristics attributed to livestock as a productive asset. Through comparing different life trajectories, the aim is to explore and reveal livestock-based rural development strategies by farmers. Farmers' life circumstances vary widely and are unique in the personal sense, but they are also grounded in shared historical events and socio-cultural norms, in which livestock represent and fulfil social and cultural values and roles. The primary data comprises 30 cases of farmers who engage in various levels of crop-livestock integration in Gisanza and Umuganura. Additionally, the life stories of the cooperative dairy member from Kigabiro-MCC elucidate two dominant strategies that emerge from the experiences of the commercially oriented dairy producers.

Introduction

In the previous chapter, the household survey analysis revealed three essential ways in which crop and livestock production interact and influence one another. Also, the propensity for crop-livestock integration and the importance of farming correlated with farmers' access to resources and different levels of agricultural asset holdings. In this chapter, I expand the notion of the multiplicity of asset attributes or 'asset-ness' to explain the dynamics of the dominant patterns of engagement of livestock in mixed farming systems (Kim and Sumberg 2015). By highlighting the interconnectedness of certain asset attributes that lead to differential adaptation of livelihood pathways and crop-livestock integration, I substantiate the argument that pathways of agricultural intensification are highly contingent on agro-ecological and socio-economic settings, but also to the inherent characteristics of livestock as productive assets.

This chapter addresses two questions. Firstly, for whom, and in what circumstances, do livestock represent a potential pathway out of poverty? To address this question, I use the

data from the life history interviews of farmers who engage in various levels of crop-livestock integration in Gisanza and Umuganura, respectively ($n_1=16$ and $n_2=14$). Additionally, in-depth interviews with the Kigabiro-MCC members reveal the different costs and risks, but also the benefits and profits accrued from intensive dairy production ($n_3=13$). Secondly, informal livestock-in-kind or in-trust arrangements are prevalent in rural and peri-urban villages. The government and international NGOs also promote livestock transfer programmes as a poverty reduction strategy (GoR 2006; Pica-Ciamarra et al. 2011; Rawlins et al. 2014). However, successful transferring of livestock to smallholders is but one step amongst many required to make an asset-based development strategy and practice work for the poor. Thus, the second question asks: what does the experience of promoting crop-livestock integration tell us about livestock asset transfer programmes and asset-based development strategies in Rwanda? In addition to the farmers' interviews, key informant discussions with the country-level managers of *Girinka*, Heifer International and Send-a-Cow help elucidate the graduation models of livestock transfer programmes and its effectiveness as an asset-based development strategy.

Crop-livestock integration and livestock as a pathway out of poverty

In the previous chapter, I used the multiplicity of asset attributes to explain how farmers from different economic backgrounds valued an animal according to their livelihood context. For instance, in Gisanza, the poor prioritised the reproduction aspect of the 'utility' of cows more than the others. Similarly, the ease of cash 'convertibility' of some livestock differently affected household's short and long-term financial plans and management. In the following sections, I employ the seven remaining asset attributes of livestock to delve into the underlying determinants that differentiate the propensity for crop-livestock integration.⁵¹

I frame the analysis by differentiating between four cases of integration. The first is the case of high level of integration where farmers successfully harness the synergy and earn profit from integrated production. The farmers in this category typically own more than two cows and farm relatively large areas of land. The second instance is when the level of integration is low, and the margin of benefit from integrated production is small. The farmers who fall into this category keep only one or a maximum of two cows and are unable to expand or intensify. The third case is when farmers are unable to integrate crop and livestock production because of

⁵¹ Hereon, I italicise the nine asset attributes for emphasis. As a reminder, they are *life, productivity, utility, holding cost, security, social relations, ownership and control, convertibility, and complementarity*. See chapter 2.

their lack of capacity and/or farmland. These farmers are unable to rear a cow but often keep small livestock. Finally, on the opposite spectrum, there are also examples of intensive dairy production where integration with crop production is limited. The life stories of the dairy farmers from the Kigabiro-MCC illustrate some of the successful commercial pathways of specialised dairy production (and examples of intensive dairy production that are financially too demanding/risky for smallholders to take) in Rwamagana.

Cases of high level of crop-livestock integration

Nearly all the farmers who successfully integrate crop and livestock production have a higher economic status (profiled as “high” integration and “rich” household status in Tables 29 and 30). The association between the two profiles begs the causal question: does high integration lead to high economic status? Or is the reverse true: does high integration strategy require a high level of resources, and therefore, better-resourced farmers have a higher chance of success with integration? The early life stories of the high integrators, namely Gahigi, Akaliza, Habimana and Mugisha, will help answer this question (Table 29).

Table 29. List of farmers interviewed in Gisanza

Pseudonym	Gender	Birth year	Interviewed	Integration	HH status*
Gahigi	Male	1955	26-May-15	high	rich
Habimana	Male	1968	04-Jun-15	high	rich
Mugisha	Male	1980	02-Jun-15	high	rich
Akaliza	Female	1990	02-Jun-15	high	rich
Garuka	Female	1953	04-Jun-15	low	rich
Isaro	Female	1980	29-May-15	low	rich
Keza	Female	1986	02-Jun-15	low	rich
Ngabo	Male	.	19-Mar-15	high	rich/middle ^α
Mutesi	Female	1945	27-May-15	low	middle
Neza	Female	1952	29-May-15	low	middle
Uwamahoro	Female	1981	29-May-15	low	middle
Nshimiye & Uwase	m & f	1949 & 1981	04-Jun-15	low	poor
Ingabire	Female	1957	26-May-15	low	poor
Rusanganwa	Male	1951	27-May-15	none	poor
Shema	Male	1955	05-Jun-15	none	poor
Mutoni	Female	1982	27-May-15	none	poor

* Household wealth standing based on asset index calculation as shown in chapter 6.

^α Although Ngabo's farmland is in Gisanza, his house is not. Therefore, his household was not included in the survey sampling. I estimated Ngabo's wealth status according to the household asset holding observation.

Table 30. List of farmers interviewed in Umuganura

Pseudonym	Gender	Birth year	Interviewed	Integration	HH status*
Amahoro	Female	1960	May-15	high	rich
Iragena	Female	1950	25-May-15	low	rich
Kampire	Female	1958	01-Jun-15	low	rich
Gatete	Male	1975	03-Jun-15	none	rich
Hakizimana	Male	1947	Apr-15	low	middle
Mugwaneza	Male	1952	28-May-15	low	middle
Nsengiyumva	Male	1960	01-Jun-15	low	middle
Siboyintore	Male	1960	28-May-15	low	middle
Mukobwajana	Female	1962	03-Jun-15	low	middle
Nkurunziza	Female	1967	May-15	low	middle
Uwimbabazi	Female	1985	28-May-15	low	middle
Iribagiza	Female	1963	Apr-15	none	poor
Mugabo	Male	.	23-Mar-15	none	poor
Nsabimana	Male	1983	01-Jun-15	none	poor

* Household wealth standing based on asset index calculation as shown in chapter 6.

Parents' wealth and past experience with livestock

Does previous experience with the family's livestock and parents' wealth matter to the current level of crop and livestock integration and economic standing? During the interviews, one of the first questions that I asked the farmers was about their childhood upbringing and their family's living standard. Without clear guidelines to upon which to base what constitutes 'good' living it is however difficult to ascertain the level of household's wealth. However, several people mentioned that what differentiated a rich family (*umukire*) from the average (*umukongo*). According to them, rich people have ample farmland and own over tens of cows; can afford to hire permanent labourers; a member of the family works in a professional job; and have something that the others in the village don't have such as a car or forest land (Keza; Akaliza, 2 June 2015). According to this standard, only one of the four integrators would belong in the rich category. For example, Mugisha and Habimana considered their family living condition as typically average. Mugisha's family had four cows, over ten goats and chicken, but the numbers dwindled with recurring household expenses (Mugisha, 2 June 2015). Similarly, Habimana's family, originally from Umutara, had eight cows, but the severe drought conditions in the early 1980s forced them to abandon their home and relocate to Rwamagana in search for water for their cows and better livelihood (Habimana, 4 June 2015).

On the other hand, Akaliza's parents had more than ten cows and eight sheep, as well as 15 goats and 20 chickens. Her family farmed over two hectares of land and also kept a hectare of forest land (Akaliza, 2 June 2015). Such an asset portfolio would be consistent with the local standard for a wealthy household. Similarly, Gahigi remembers growing up with a large herd of cattle. His grandfather had over sixty cows, of which four belonged to his father. Gahigi's family pooled their cows together as it was more economical to pasture in a herd (Gahigi, 26 May 2015). However, a disease outbreak in 1967 wiped nearly all the family cows, and Gahigi's father left home in search of replacement cows to Uganda. His family faced further challenges when his mother passed away in 1972, and at the age of seventeen, Gahigi became the head of household and took charge of his younger siblings. The drastic change in family wealth in Gahigi's case sets the premise for the next hypothesis. That is, without the security of transferring of productive assets, the family's original wealth and living condition will have no bearing on the current level of integration and wealth status. Therefore, the causal link between the families' initial and the current wealth will be weak in the presence of severe livelihood shocks and crises (but also just bad luck or poor judgement). Indeed, the genocide in 1994 proves to be the most historically significant but also a life-shattering event for many of the interviewed farmers.

Rebuilding life after conflict: the resilience factor

The violent conflict and massacre against the Tutsis and the moderate Hutus in 1994 affected all the interviewed families who lived through the genocide. Some families were luckier than others, but many of them lost family members, homes, and livestock. Many survivors still live with permanent mental and physical injuries and disabilities. What is interesting to note from their post-conflict experiences is their varying ability to recover from their loss. For instance, Mugisha's family lost all their animals and household assets, except for his house. Worst of all, however, was the death of his father during the genocide. Mugisha had to carry on with farming to support the family. He began growing sorghum for cash sales and sweet potatoes for home consumption. Eventually, with the money he saved from selling sorghum, Mugisha bought a goat, and by 1998, he managed to cultivate all the family plots (two hectares in total) and to purchase and keep a bull and two goats (Mugisha, 2 June 2015).

Gahigi's life was well established before the genocide. In 1992, he married a second time, and he was buying more land and expanding crop production. He was also generous with his wealth and used to give cows to his close friends. The genocide changed everything. None of the livestock survived, and he lost his house. Fortunately, his relatives and friends came quickly to his rescue. Two of his friends and his father-in-law each gave him a cow to help him re-establish. He also brewed and sold banana beer to buy another cow. He was also allowed to stay at a neighbour's place while he was saving money to rebuild his house. With the donation of five corrugated metal roofing sheets from a friend, he completed the construction of his new home in 1997.

Habimana also recalled the devastating reality of his post-genocide experience. The perpetrators of genocide looted everything they could find at Habimana's residence. They stole all the animals and household goods, including all the doors and metal roofing sheets. The only thing they could not take was the land. Habimana began to farm and slowly started to rebuild his house and recuperate household assets. Here is how Habimana described the path of recovery.

In 1995, I bought a local cow [*Ankole*]. Cows were cheap at the time. I paid around 18,000 to 19,000 RWF. I also purchased a sheep and chicken. As my cow reproduced, I was able to sell the offspring and save enough money to buy more land. The crop yield also improved with more cows as more manure was used. [...] It took us four to five years (from 1994 to 1998) to rebuild our life. Our living conditions were again back to normal and we were able to meet our family needs. Since then, our livelihoods improved every year. (Habimana, 4 June 2015)

By 2012, Habimana has managed to increase the number of cows to four with the first cow that he purchased in 1995. As for the crop and land expansion, he quadrupled the size of farmland from 0.5 to 2 hectares (Habimana, 4 June 2015).

Akaliza's post-genocide experience illustrates an entirely different set of circumstances and outcomes. Firstly, all her family members survived the genocide, and all their belongings, livestock, and the house were left intact. All the children returned to school in 1995. Upon completing their secondary studies, some of her older siblings left home to find work in Kigali. However, a turning point happened in 1997 with an attempted robbery that killed her father. A year after her father's death, her mother fell ill, and she could not maintain the farming work. They hired farm labourers, but paying their wages became more difficult. The family sold two cows that year. Akaliza's mother stayed bed-ridden for another year (1999-2000), and Akaliza stopped going to school to help with household chores and livestock rearing. The family sold another two cows to keep up with the house renovation and medical expenses. Fortunately, her mother recovered, and she started to work and farm again. Akaliza resumed her study, and their crop and livestock production slowly increased. By 2001, the family had eight cows and hired several labourers to run both crop and livestock production. However, the family's living conditions were once again upset when her older brothers from Kigali came to take and sell the family cows. Akaliza remembered the incident.

We asked the district officers to help mediate the situation so that our brothers return the family cows. We didn't have any cow for the next six years. We reared small animals such as chicken and goats during this time. We also used the (small livestock's) manure, but it was not enough, and our harvest yields declined. We tried increasing small animal production, but the house repair expenses required more money, so the animal numbers kept low. (Akaliza, 2 June 2015)

In 2006, the family misfortune continued with her mother suddenly falling ill and passing away in just two days. Akaliza was 16 years old at the time, and an older (female) cousin who was an orphan of the genocide came to live with her and her younger siblings. Her cousin worked and farmed the family land and took care of the family. A year later, Akaliza finally settled the disputed case against her brothers, and they received three *Ankole* cows.

In sum, nearly all the interviewed families were severely affected by the genocide. Despite the significant loss, Mugisha, Gahigi and Habimana found the means to rebuild their livelihoods within three to four years. For Mugisha, selling sorghum provided the initial capital necessary to buy his first goat which eventually led to procuring a bull. Generous friends and families

provided cows and shelter for Gahigi. As for Habimana, his life improved slowly but steadily with increasing production from one *Ankole* cow and a half of a hectare plot. Although it took him over 17 years to establish the livelihood that he enjoys today, his life story sets an example of successful crop-livestock integration. In the case of Akaliza, the family's original wealth and assets were not affected by the genocide, but the illness and death of her parents as well as the feud over family cows downgraded the family's living conditions and hampered crop and livestock integration for over six years. Besides hard work and social support from neighbours and families, what other factors and strategies have the integrators attributed to their success in integration?

Husband and wife as a team

For Gahigi and Habimana, one of the critical factors of success in integration was the harmonious working relationship with their wives. Gahigi explains the growing success of the family farming.

Today, I have 14 hectares of forest land and six hectares of farmland. I was able to purchase more land by selling crops, but also because I was able to work well with my wife. We understand well each other, and we make a good team. (Gahigi, 26 May 2015)

While both crop and livestock farming is equally crucial for successful integration, the daily labour demands of crop and animal production are very different. The extent of workload for annual crop production, taking maize, for instance, peaks at the beginning of the rainy season. Before the rains, the primary work involves land preparation and sowing, and then, harvest work requires intense bouts of one to two weeks of labour. But once the rainy season begins, the workload reduces to more regular but light maintenance of weeding and pest and disease monitoring (Nkurunziza, May 2015). Livestock management, on the other hand, involves constant sourcing of grass (if zero grazing) or round-the-clock herding (if pasturing). The work may not be as demanding as crop farming during the peak labour periods, but the constant involvement and care for the animal require a punctual and reliable labour force. Consistency in feeding, milking and caring work is vital for lactating cows. For these reasons, keeping a healthy and productive dairy cow demands constant and highly reliable care work.

Table 31. Habimana and his wife's daily schedule

Time	Husband	Wife
4:30 – 5:00	Wake up and milk the cows	Wake up and milk the cows
5:00 – 6:00	Bring milk to the market	Bring grass and feed the cows
6:00 – 7:00	Return back from the market	Work in the field
7:00 – 11:00	Work in the field	Work in the field
11:00 – 16:00	Eat lunch and rest	Prepare lunch and eat, clean and wash dishes and rest
16:00 – 16:30	Milk the cows	Milk the cows
16:30 – 19:00	Bring milk to the market and back	Prepare supper
19:00 – 21:00	Eat supper, rest and attend village meetings if needed	Eat supper, clean, wash and rest
21:00 – 4:30	Sleep	Sleep

Source: Excerpts from Habimana, 4 June 2015.

Similarly, Habimana credited the excellent teamwork with his wife as one of the most important factors in the success of their crop and livestock integration (Habimana, 4 June 2015). For instance, Habimana says he discusses all aspects of farming and animal rearing with his wife before making any decision. They work on the same plot and coordinate the animal rearing tasks. Their typical day's schedule in Table 31 illustrates the close level of coordination.

Entrepreneurial initiative and access to financial credit

A drive for self-improvement was a key factor in the success of Mugisha. Mugisha was one of the earliest adopters of crop specialisation and zero grazing practice that the government introduced in 2002. He admits that both zero grazing and crop intensification are labour intensive, but he achieved greater yields and more income from farming in this way than when he used to intercrop. Once he began noticing the increases in crop yields, he voluntarily joined a government initiative and attended a training-the-trainers programme. His willingness to experiment with new production methods prepared him for more ambitious projects. Mugisha recounted his rapid production expansion and savings strategy.

I was able to save more money quickly thanks to the village savings groups [rotating saving and credit associations]. Besides the savings, I also sold banana and milk. The savings grew. [...] I participated in several saving groups (three) and with the growing savings I bought goats. I also borrowed money from other savings group and bought a male calf. I paid back the loan by selling banana and the daily money that I received from participating in the training of the training programmes. I was able to save extra, and the number of livestock increased. I continued to re-invest and save. In 2005, I bought my first crossed breed calf (for 72,000 RWF). (Mugisha, 2 June 2015)

With snowballing savings, Mugisha realised how quickly he could increase production by borrowing and investing in farming assets. The financial assets that he secured over a relatively short period gave him the confidence to take on a bigger loan.

In 2008, I decided to buy a pure breed cow. I took a bank loan (of 700,000 RWF) and sold the crossed breed cow. With the credit and the money from the sale, I built a modern shed (costing 400,000 RWF) and bought a pure-exotic cow. With increased milk production, I was able to pay off the debt in seven months (instead of 12). The cow produced 20 litres of milk per day. In 2009, I took another bank loan of 2 million RWF. I bought a plot of one hectare for forage grass and banana production (costing 600,000 RWF). I also bought two pure breed exotic cows (costing 650,000 RWF) and I built a bigger shed (costing 500,000 RWF). Now with three pure breed cows, the milk production increased to 40 to 50 litres a day. (Mugisha, 2 June 2015)

While farming and animal rearing are an essential part of the family livelihood, however, Mugisha is more interested in agri-businesses and entrepreneurial initiatives. In 2010, he decided to take yet another loan – this time, worth four million RWF – to help pay off the previous one (two million RWF) and to invest in commercial businesses.

In 2010, I tried to pay back the loan as soon as possible – i.e. in one year instead of two. So, I borrowed again (worth four million RWF) to build a new house and commercial store and a milling machine. I was confident that the higher milk sales would pay off both loans on time. With the money, I installed electricity at home (500,000 RWF), bought a motorcycle (one million), a new building adjacent to the house (one million), a hectare of land (1.5 million for crop and contour grass production), and a pure breed exotic cow (550,000 RWF). (Mugisha, 2 June 2015)

The rapid growth of Mugisha's agricultural enterprise is a remarkable example of what at least some rural entrepreneurs can achieve with financial resources and capital investment. He believes that many people are afraid of taking a bank loan because they have a high aversion towards risk and loss (Mugisha, 2 June 2015).

The one-cow production: a question of affordability

Ngabo and his family were part of the diaspora in Tanzania, and they settled in Rwamagana when the genocide ended (Ngabo, 19 March 2015). He used to work as a commercial driver, but in 2009, he used his savings to buy land and cows, and began farming in Gisanza. In total, he farms four hectares of land on which he cultivates banana (on one hectare), groundnut (0.5 hectares), and soybean (one hectare), and rotates beans and maize production on another plot (0.5 hectares). He also grows forage grass on a two-hectare plot. Initially, he used to keep seven local cows, but he sold them, built a bigger cowshed and bought one cross-breed cow.

Ngabo copes with the decrease in manure production by applying micro-dose of chemical fertiliser and composted manure in the seedling hole. He learned this method – similar to the technique originally known as ‘zaï’ in West Africa (Reij et al. 2013) – during the field training and study tour sponsored by the milk cooperative (Kigabiro-MCC). Ngabo mainly feeds his cow fresh grass. During the dry seasons, however, he includes silage made from maize leaves and leaves from *Mucuna pruriens* beans and *Calliandra* trees. When the cow is lactating, he also supplements the diet with maize bran. When asked whether crop or livestock production was more important for his family, he jokingly exclaimed: “You wear both the shirt and the trouser, right? Likewise, crops and animals must be grown together” (Ngabo, 19 March 2015). He continued to explain.

Specialising in milk production is for wealthy people who can afford large plots for grazing and fodder grass production. For me, (and the farming conditions that I am currently in), zero grazing is the only way I can afford to keep a dairy cow. Under this practice, I can only rear two or maybe three cows. (Ngabo, 19 March 2015)

Ngabo’s assessment may come as a surprise given his access to ample farmland for both crops and forage production. There are two remarks worth highlighting. Firstly, he makes a clear distinction between the specialisation and integration pathways. The pre-requisite for the former is pasture land. For the specialisation, the land management decision is based on the dairy and forage grass production. Livestock integration with crop production is no longer a priority. Secondly, Ngabo stresses the issue of affordability of integrated production systems. The most critical account from Ngabo is that he could not imagine rearing (“afford”) more than two or three dairy cows even with the best conditions. The high cost of zero grazing is a severe constraint for Ngabo. In the next section, I further explore the question of affordability from the perspective of the farmers who are not highly integrated.

Cases of low level of integration

Farmers whose crop and livestock production are not closely integrated come from a range of economic backgrounds (Table 29 and 30). For the farmers in the middle and the poor categories, affordability may be the leading cause of weak integration. Although they may grow grass on plot contours, the amount of fodder they can produce in this way is marginal. Nearly all the interviewed dairy farmers had difficulties feeding their cows during the dry season and many could not afford to buy fresh grass and feed supplements (chapter 6). Moreover, free grazing is no longer possible in the new settlements (*imidugudu*) because of the shortage of public grazing area and the lack of secured perimeters around the farmland. The zero grazing model means that everything needs to be brought into and taken out from

the shed manually. Primary inputs include fresh forage grass, water, and visits from veterinarians. As for the output flows, farmers need to clean the shed, collect and compost manure and litter, and transport milk once or twice a day to the market if the cow is lactating. Therefore, rearing a big animal in a confined space is time-consuming and labour-intensive work. Although by definition, a family farm relies mostly on household labour, however, it is not uncommon to find families hiring labour even at a small scale of production.

Livestock as an old age security asset

Mutesi is seventy years old, and she lives in Gisanza. Her family's living conditions drastically deteriorated when her husband died from cholera in 2000 and she assumed the responsibility for farming. Her two sons did not contribute to the farming as one was still in school and the other worked as a trader and was always travelling.

I was the only one farming. We became worse off. My husband and I used to grow enough food for the family, but since my husband died, the production yield is much less than what it used to be. Our living conditions didn't get better since then. No one helped me. The cows that I have today are my son's. The cows are kept here (in care of), and in return, I get to sell and drink some of the milk and use manure. When I sell milk, I first pay the cowherds. I also get to save some money to buy clothes and food. My son keeps the earnings from selling the calf. I have no specific plans for the near future. I am weak, and I suffer from diabetes. I can't add more land or keep more animals. I'm not happy with my situation, but there is nothing I can do to improve or change these conditions. (Mutesi, 27 May 2015)

There are three relevant asset attributes that the entrusted dairy cow exemplifies in this case. The first is *social relations*. In the absence of old age security, the son's dairy cow is a valuable livelihood and old age security asset for the elderly mother. Although the *productivity* attribute may be low, one-cow production generates enough milk for home consumption and some income for basic needs. The third has to do with the *ownership and control*. While Mutesi has access to milk and manure, she has no rights over the cow and its offspring. However, even if she could negotiate better terms and gain full control of the cow, this gain would do little to address challenges associated with her advancing age and ailing health.

Family lifecycle

What about the families who have the labour and are eager to enhance productivity through one-cow production? Can they expand and intensify their production? There are examples of families who have all the necessary assets and are earnestly engaging in crop and livestock integration but can still only manage a low level of production and integration. The life stories

of Ingabire, Nshimiye and Uwase exhibit a very positive experience with livestock keeping and the influence it has had. Ingabire remembers growing up in a large family. She was the eldest of her ten siblings. Other family members included her grandparents and seven cousins. Her parents owned five large plots of land and 16 cows. She helped with farming and taking care of the family cows. She recalls her life back then as “good and pleasant” (Ingabire, 26 May 2015). However, the family’s living conditions suddenly deteriorated when four of her older male cousins asked her father to share the family land with them. They were of marriageable age, and they needed the family’s help to establish themselves on their own.

This request forced my father into a very uncomfortable situation as our land was already too small to share amongst us (his 11 children). My father, however, decided to share his plots with our cousins. This decision negatively affected our livelihood as we could no longer feed our cows with the reduced size of land. We had to sell our cows, and my father reduced the herd to seven cows. (Ingabire, 26 May 2015)

Ingabire left home in 1980 and joined her husband and her in-laws in Mwulire. Her parents’ livelihood improved when Ingabire and other siblings got married and moved out.

I didn’t claim the share of the family land, but in exchange, I asked my father to give me a cow. When my other siblings moved out, they also gave back their share of the land and asked for a cow instead. My parents’ living conditions improved significantly as more land was available for them. They kept three cows. (Ingabire, 26 May 2015)

The Chayanovian family labour model explains that household consumption demand and labour supply fluctuate with different phases of the family’s life cycle (Chayanov 1986 [in Russian 1925]). In the rural context in Rwanda, the passage to adulthood triggers the transfer of productive assets from the older generation to the younger including land, cows or money which can be used to build a house. The transfer of assets can also affect the family’s living conditions negatively. Take for example the husband and wife, Nshimiye and Uwase. Uwase had a problematic first marriage, which ended after two years of disagreements, misunderstandings and failed reconciliations. She took custody of their child and moved back to her grandfather’s home in Gisanza. In 2006, she married Nshimiye who is much older than her. Despite the age gap, they get along very well and work closely together and consult each other for all farming and livestock rearing decisions (Nshimiye & Uwase, 4 June 2015). All was well until 2014 when unexpectedly, Nshimiye’s sons who are already well established requested their share of family land. Although neither of them elaborated on this family ordeal, seeing the progress they had made and the savings they had accumulated through crop

and livestock farming over the years quickly dissipating was a devastating setback. Nshimiye is disappointed, but he knows how to get back on track.

I will keep rearing cows and start milk production again. With the milk I get, I will sell and save money to buy more land. With more land, then I will be able to increase the herd size. And then I will continue and repeat this cycle (buying more cows, then buying more land, and keep on saving more, and so on). I have been successfully developing and progressing using this strategy, but the unexpected needs (my sons' requests) interrupted my plan, and I have to start all over again. (Nshimiye and Uwase, 4 June 2015)

While the process of accumulation generated through livestock production that Nshimiye is describing seems straightforward, in reality, the rural livelihood pathways resemble more of a snakes and ladders game. Natural events such as drought, flood and accidents and illness, but also, chronic health problems and ageing-associated disease, as well as a successive row of rising tuition fees can deplete and the family's savings and assets back to square one.

Pathways out of subsistence farming

The cases of Keza, Iragena and Kampire highlight contrasting reasons for the low level of crop and livestock production – and integration – amongst the wealthier group. One feature that these women share is their aspiration for professional work. For instance, before marriage, Kampire worked as an accountant at a furniture store in Rwamagana, and Keza as an office clerk at the Rwanda Revenue Board (Keza, 2 June 2015; Kampire, 1 June 2015). Kampire is originally from Nyanza district (Southern province), but through a friend she found a job in Rwamagana and moved there in 1977. Her monthly salary at the time was 1,500 RWF, and even after paying for all her living costs (about 500 RWF) and sending remittances back to her parents, she was able to save some money (Kampire, 1 June 2015). Kampire's professional work, however, was short-lived as she found favour with her employer who was also the carpenter and owner of the furniture store and become his second wife. Kampire recollects the event and the implications it has had on her life.

In 1979, I married my husband. Well, in fact, it was a forced marriage. They kidnapped me, and my boss proposed to me. I was shocked at first, but I accepted the situation, and I became his second wife. [...] I lived in a separate house. I stayed at home and raised the children. In the beginning, I didn't have to work and farm – we hired farm labourers. In 1986, after I had my third child, I started to farm. We had large tracts of farmland, and we were able to meet all our food needs. We also had animals at home (two cows and pigs). We hired a (permanent) labourer to take care of the animals.

Although all the family needs were met, I didn't have any means to save. Whenever I needed money, I had to ask my husband. (I was very dependent on him) [...] My husband sold a part of the land that I used to farm. He made a lot of money (from the sale). However, for me, this loss of plot meant I couldn't fulfil all the food needs at home. So I had to buy some food from the market. (Kampire, 1 June 2015)

Although her husband kept tight control over the finances, he always ensured that the household's needs were met adequately. Even after his death, Kampire managed to retain some of the family land, to which, legally, she has no entitlement.

In 2004, my husband died. I was able to inherit some of the family lands, but legally I was not entitled to any of my husband's property. At first, all the first wife's children refused to share the inheritance with me. They asked me to keep the house but to give up the land. I pleaded and negotiated so that I can keep the house and whatever field that I used to farm. (Kampire, 1 June 2015)

Kampire's livelihood drastically changed after the death of her husband.

In 2006, I got a loan, and I started brewing banana beer. With the money I made and saved, I was able to open a local bar. I operated this business for three years until I converted the bar into a rental accommodation housing. I continued to build more and extend the use of my house for commercial purposes. [...] My husband never took out a loan in his lifetime – he was afraid of the risk. However, I don't mind (the risk). (Kampire, 1 June 2015)

Kampire's entrepreneurial spirit and risk tolerance may have been dimmed by her husband's financial control over the years, but it never died out. She is keen on expanding her newfound business interests, and she has started to phase out of farming.

Since the soil (fertility) wasn't very good, I slowly switched my attention away from farming to commercial businesses. I hired farm labourers, but the productivity was low, so I decided to sell some part of the land and build another house. (Kampire, 1 June 2015)

Keza's family story reflects a critical phase and characteristic of a young family. Keza worked at the Rwanda Revenue Board office in Rwamagana, and she continued to work even after she married and had her first child. She is also an avid learner. While she was working and parenting her first born, she enrolled for a bachelor's degree at the local university. She continued to study until 2014, but finally, she decided to take a leave with the arrival of her second child. Since then, she has stayed at home to take care of her toddlers. Although the loss of Keza's income had a slightly negative impact on the family living conditions, her husband's salary as a public servant in the sector office is enough for her to take leave from

work. Keza is not interested at all in farming, but her husband is keen on rearing livestock and cultivating the land.

In 2014, we bought a cow. We are now getting milk and manure. Our children are still young, and we need milk at home. Keeping many cows is not a good idea though. Maybe having two cows will be ideal: I will be able to feed them adequately, which will ensure good milk yields. Having more (than two) cows would be unprofitable. [...] Eventually, I will find another job. Farming and animal keeping is difficult. I wouldn't mind leaving (and not farming) entirely. However, my husband is knowledgeable about farming, and he likes to keep animals and cultivate the land. (Keza, 2 June 2015)

Keza is not interested in farming but still keeps a cow and cultivates crops to support her growing children's diet and contribute to family food consumption. What is interesting is that although they have the financial means to source all their food and milk from the market, they continue to grow their own. Therefore, the incentive for intensification and commercialisation will be weak in a situation when a wealthy family engages in production for hedonistic purposes, almost as if it was hobby farming. Failing to understand the farmers' motives and production objectives may also lead to ineffective and costly policy initiatives. For instance, families like Keza will be less than enthusiastic about any intervention to boost production through integration, because their *utility* for rearing a cow is not geared towards higher *productivity*.

Unlike Keza and Kampire, Iragena has always worked in family farming. The decision to pursue a higher education or a professional career was not an option for her. In 1961 when she was eleven years old, the anti-Tutsi sentiment amongst the people was widespread. Violent attacks and civilian killings were frequent, and the climate of complete impunity caused a massive exodus of Tutsis to neighbouring countries. Iragena stopped going to school and stayed home and helped her mother with farm work. Farming was central to her family, and agriculture was the women's domain. Her father was a cook at St Aloys, a local Catholic monastery, and her mother took charge of farming (Iragena, 25 May 2015). In addition to subsistence farming, their primary financial incomes consisted of artisanal production brewing banana beer and weaving mats and also her father's salary. This kind of mixed portfolio livelihood continued to be a strategy for Iragena. Coincidentally, like her father, her husband worked as a cook at St Aloys, and like her mother, she took responsibility for farming. Crop-livestock integration is not her priority anymore, however.

We prefer not to have many cows (we currently have two). We cannot manage more than two because of lack of space and grass production. In

2000, my husband stopped working (for St Aloys), and he started making juice from pineapple (we buy the ingredients from other farmers) and banana (we use our own). We are trying to grow this business and build a large factory. If the business flourishes, I will still keep the same number of cows, but I will not expand the production. None of my children is involved in agriculture, and I don't think any of them will farm nor keep livestock in the future. (Iragena, 25 May 2015)

Having a family member who has a salaried job can contribute significantly to the family's income and lessen the reliance on farming. The lack of family labour also constricts the extent of integration. Therefore, integration between crop and animal farming activities is not a priority for these families. Iragena's case is not a complete "exit" from farming. Her fruit juice processing business involves transformation and value addition. Therefore, it is possible to envisage a transitory pathway from a small-scale, poorly integrated production to a more specialised agri-business enterprise.

Cases of no integration

In the previous section, I highlighted the question of affordability of crop and livestock integration. The poor farmers also reflected on the issue (Table 29 and 30). The life stories of Rusanganwa, Shema, Mutoni, Iribagiza, Mugabo, and Nsabimana reveal why they are unable to engage in crop-livestock integration and the significant issues that barred the development of their livelihoods.⁵²

Lack of basic access to land and housing

Unfulfilled basic needs and a lack of the resources required to earn a living (i.e. start-up assets) was the leading cause of no integration. The pre-requirements and start-up assets comprise of living in their own house and having access to some farmland and livestock. The first and foremost asset amongst the three is housing. None of the poor had secure tenure to their housing, and most of them were on monthly rental contracts, but in some cases, people lived in temporary residences. The latter case involves an informal arrangement with the absentee owners who seek in residence caretakers. Here is an example of Mutoni's arrangement.

In 2012, we moved to Rwamagana. My brother-in-law who lived in this region introduced us to a friend who was looking for someone to take care of his house, farmland and cows in Gisanza. The owner provided free

⁵² The case of Gatete is very different from the rest of the group, and I did not include his story in the analysis. Gatete and his wife are both working professionals, and they don't have the time and land to rear any animals. Gatete sees potential in agri-business but he is unsure how he can manage his work and family time to embark on a new farming project (see Table 30; Gatete, 3 June 2015).

accommodation, access to the farm (we get to keep all the harvest) and manure (available once the owner uses first on his banana plantation). In return, we take care of his livestock (cows, sheep, pig, chicken and goats). All the animals and the profit from their production go to the owner. (Mutoni, 27 May 2015)

The arrangement offers a temporary financial relief for Mutoni and her family, but the likelihood of generating a surplus and accumulating savings is slim.

The major constraint is the small land. We get very little yield. I hope things will improve with God's help ... Eventually, with the future savings, we plan to buy our own land here in Mwulire ... Then, we will get our own livestock. (Mutoni, 27 May 2015)

Similarly, Rusanganwa's family has lived at a friend's residence since 2007. Rusanganwa's life has been marked by a series of misfortunes and setbacks. His family survived two violent conflicts (one in 1959 in Rwanda and the other in 1983 in Uganda), and each time, they lost all their productive assets. He divorced his (second) wife recently, and he is now a single parent to four children (Rusanganwa, 27 May 2015). The in-residence arrangement is a lifesaver for Rusanganwa, but it is not a secured proposition.

In 2007, a friend lent us his house that we are living in now, a land to cultivate and rear his cows for him. I can farm and keep all the harvest for myself, while I live in this house for free. I also take care of his cows. We share the milk production, but the offspring belong to my friend. This arrangement is not a permanent deal – I may have to move out on short notice. (Rusanganwa, 27 May 2015)

It is difficult to imagine how Rusanganwa will break out of this poverty trap. He explained his biggest challenge and how he believes he can overcome it.

The biggest problem is that land is costly. Those who have a job and earn a salary can save enough to buy property. I am getting older and weaker. It is hard for me to work more and I would need more labour to help me expand the production. Then, I need to pay more money for the labourers. The cost of production will increase, and the profit would be less, or worse, it may no longer be profitable. Only if I have my land, I can grow it slowly at my own pace without the added pressure from rental land production. Then, I will be able to own a house and cows. That's the way how I can improve my life. (Rusanganwa, 27 May 2015)

As Rusanganwa pointed out, at the heart of the poverty trap is the question of access to basic resources. In a smallholder context, without the *ownership and/or control* of land, none of the other productive assets such as labour and livestock could be utilised. In other words, it is the

complementarity between soil, crop, family labour and livestock that enables higher levels of crop-livestock integration.

Despite the cadastral framework and formal land tenure system, access to and control over land is still hotly contested in rural villages. Many families suffer from extended and ongoing legal cases, delays in compensations and lost development opportunities. Nsabimana and Mugabo's families recently moved to Umuganura. Both families left their hometown because they lost access to their family land. Mugabo is from Cyangugu. He used to have a hectare of land near the Lake Kivu, but he lost the entitlement to the government, because of a new land law that claimed all land within 50 metres from the water as the buffer zone (GoR 2013c). Making matters worse, he did not receive any financial compensation for the loss. He subsequently sold his house and moved to Rwamagana (Mugabo, 23 March 2015).

In the case of Nsabimana, the problem began when his parents passed away while he was still too young (at 13 years of age) to take charge of the family land. Despite his young age, he decided to quit school and stay at home to farm. His elder brothers sent money regularly to hire labourers. In 2004, at the age of twenty-three, Nsabimana and his wife started to farm full time. However, in 2006, he mysteriously fell sick and was unable to work. He believes that some of his relatives are envious of his land.

In 2006, I fell sick from the 'poisoning'. I suspect that some of my relatives are behind this curse. All my siblings have left and started their life away from home except for me. As I was getting more independent (coming to age) and seeing me married and settling down meant that the family land that would have been available for them would no longer be. When I fell ill and couldn't work (for a year I was bedridden), the relatives farmed on our land. We called for a family meeting to discuss the matter. My other two brothers who lived in Kigali at the time came back to Nyamagabe to help settle the case. We couldn't resolve the problem. My eldest brother suggested that I come live with him (in Rwamagana) and move away from the family quarrel. I left Nyamagabe in 2007. (Nsabimana, 1 June 2015)

Since then, Nsabimana has been renting plots to farm and living at his brother's house with his wife and three children. Farming is their only economic activity, but they can barely keep up with the family expenses and the rental costs. Many of the poor farmers I interviewed lacked most of these essential start-up assets, but also, some of them suffered from adverse events that are beyond their means and capacity to overcome. Shema's extraordinary life story illustrates this.

Livelihood shocks and crises

Shema was born into a wealthy family in 1955. His parents farmed on over ten hectares of land and reared 50 cows and many small livestock (Shema, 5 June 2015). In 1980, when he was ready to marry, his parents paid for his house, gave him five cows and a small plot (0.30 hectare) to start on his own. Life was good back then, and he was “well set for a good start (cows, large plots of land to choose from, and the house)” (Shema, 5 June 2015). Shema and his wife managed to increase up to two hectares of land and ten cows in just four years. In 1990, he met some relatives of a neighbour from Tanzania. He was impressed by their stories about the fertility and productivity of land in Tanzania. The soil on his farm had become poor over the years (he didn’t use manure back then) and he decided to move his family to Tanzania. Upon arrival, he purchased four hectares of land that was previously uncultivated, and three cows. The family’s wealth grew steadily up until 2013, but most unexpectedly, he lost everything overnight. He recounts the event.

In 2013, there was a regional security talk in Ethiopia between the heads of states of the East African region. The Tanzanian president [Jakaya Kikwete] and president Kagame disagreed over the issues concerning the *Forces Démocratiques de Libération du Rwanda* (FDLR). So afterwards, Kikwete announced publicly on the radio that he didn’t want any Rwandan in Tanzania. People took the president’s words seriously. My friends in the village turned against the Rwandans overnight. The village security informed me to vacate the land and the house. But, I didn’t listen and went to the market with my son to sell a goat, and from there, I was stopped and deported straight away. All the Rwandans and other nationals from regional countries were arrested, loaded into military trucks and sent to their respective borders. I heard from a source that my wife passed away. The other two children are still in Tanzania. I couldn’t bring anything back with me. I have no right to return, no claim over my assets and land. (Shema, 5 June 2015)

The diplomatic fallout resulted in the eviction of thousands of Rwandans from Tanzania.⁵³ For the next two years, Shema moved from one refugee camp to another, and in 2014, he found an in-residence arrangement in Gisanza. However, the deal fell through in less than six months.

I used to work as a day labourer at a nearby village called Rukara. The plot belonged to the local police station. The police chief asked me to work on his (personal) farmland. He promised that he would help us (my son and me) find our own house and teach my son driving. I accepted the offer, and

⁵³ For more details on this event, see <http://www.dw.com/en/rwanda-tanzania-mend-diplomatic-relations/a-19170998>

we came to Gisanza where his farm was. From July to December 2014, I took care of his land (I received a salary), and I grew tomatoes on the side for myself. However, when the chief found that I was producing tomatoes, he was not pleased and said that I broke the trust and chased us from his land. He probably wanted someone who would stay in the longer term as a farm labourer. Seeing that I was trying to make extra money from tomato sales, he was afraid that I would leave soon. (Shema, 5 June 2015)

Since then, Shema and his son have lived in a rental house. He still doesn't own any land but managed to get access to a small rice plot in the marshland that is part of the Land Consolidation Programme. His outlook on life is brutally honest.

I have no foundation to build my life back. Only God can help. Renting (the house) doesn't allow me to save or to buy any animal. Renting expense is the most urgent and recurring priority. The current rental deal is affordable, but if the landlord decides to change the terms, then I may have to move out. [*I asked what else can be done to improve his livelihood*] If I work harder, it is for nothing (futile). (Shema, 5 June 2015)

For farmers like Shema who have no regular income, all financial decisions revolve around paying the monthly rent. When nearly all the earnings go to rent and food, it is impossible to save or buy any livestock. In theory, *Girinka* cows or an *indagizanyo* contract for a small animal such as a goat can be a significant relief for families who have no means to save or accumulate livestock assets.

Livestock transfer and livestock-in-kind arrangements: An asset-based development strategy for the poor

About a quarter of the sampled households in the two villages had no livestock (chapter 6). There were various reasons why these families could not (or did not) rear animals, the main one being a lack of initial capital to invest in livestock, and the animal disease and distress sale that reduces previous holdings. The practice of livestock-in-trust or loaning scheme (*indagizanyo*) is common in the region. For the farmers who lacked the means to buy their animals, I asked if they knew about alternative ways to obtain livestock. Most of the farmers knew about the livestock-in-trust schemes (both publicly funded *Ubudehe* and *Girinka* programmes and the locally arranged *indagizanyo* contracts) but faced challenges accessing these. Some farmers had moved to the village recently and didn't know anyone to ask for an in-kind contract. Others had negative experiences from previous *indagizanyo* engagements, or just disliked the risk associated with keeping someone else's livestock. Chief amongst the challenges, being unsettled was the most common reason for not rearing a livestock – especially where families have not yet purchased their land and housing. For instance, 9 out of

21 families had either been recently moved to the village or newly married, and therefore, they were living in rental accommodation. The families on rental contract explained that their neighbours may be reluctant to lend their animals due to their impermanency.

Livestock-in-kind for the poor

Mugabo and Nsabimana are both newcomers to Umuganura, and they are in the process of integrating into the village. Building good relationships with neighbours is an important part of this process for recent settlers. In 2013, Nsabimana approached a neighbour and asked him for a goat. The risk for an in-kind goat contract is much less than a bigger animal such as a cow, and the shorter reproduction cycles make the arrangement more affordable for the poor. Mugabo related his experience.

In the past two years, the mother goat gave birth twice, and each time, we had two kids. The owner (my neighbour) and I kept one (kid) each time. The goat was pregnant for five months. If it is well fed and maintained, it can be pregnant again in two months after the delivery. (Mugabo, 23 March 2015)

Nsabimana also arranged a similar *indagizanyo* contract.

If we get two kids, then we each take one. If we get three kids, then the owner will get two, and I will have one. I will complete another round of pass-on, and then we will decide if we continue further or I return the mother goat to the owner and end the contract. (Nsabimana, 1 June 2015)

The agreement also made provision for premature deaths and infertility.

We (both the owner and I) will share the loss. There will be no blame. If the goat doesn't reproduce, then we can sell and buy a new goat. If the replacement goat is more expensive than the sales revenue that we get from the old one, then the owner will pay the difference. Also, if we decide to cancel the contract, then we sell the goat and split the sales revenue. (Nsabimana, 1 June 2015)

However, despite the high reproduction rates and rapid pass-on, some poor farmers are incapable of growing a herd because of the recurring family expenses. For Mugabo and his family of nine children, the revenue generated from goat production is "not enough as [he] spends almost immediately for household expenses" (Mugabo, 23 March 2015). Although goats are excellent for smoothing the household's short-term consumption needs, the revenue generated is not sufficient to accumulate any savings. Instead, farmers use bigger animals such as cows as a long-term investment for accumulation.

Some farmers managed to obtain a cow through an in-kind arrangement similar to that used to access goats. For instance, Nshimiye kept a friend's cow after selling his only cow and giving away his land to his sons. The agreement was based on the goodwill between the owner and Nshimiye. Both parties negotiated the terms and conditions of the engagement. For instance, as a trustee, Nshimiye took on the cost of feeding and keeping the cow healthy and productive until it successfully delivered the agreed number of offspring. The owner would take the first calf, and the second one would belong to the trustee. At that point, the contract may come to an end, and Nshimiye would return the original mother cow to the owner, or they could start another round of reproduction and pass-on. In principle, the livestock-in-kind contract offers a scenario that satisfies the needs of both parties while spreading the risk and costs of livestock production. In practice, however, the informal arrangements can quickly dissolve, with neither of the parties being protected from loss. Nshimiye told of a negative experience with an *indagizanyo* contract.

I used to keep another cow under a similar arrangement. Once the first calf was born, the owner came and told me that he would sell the mother cow and buy a more productive dairy cow. He gave me 2,000 RWF at the time [which is less than 3 USD]. He took back the mother cow and the calf and never came back! We never had an official agreement, and I couldn't make a formal complaint. (Nshimiye & Uwase, 4 June 2015)

Farmers rarely draft a more formal agreement. Nshimiye explained: "I am the one who is asking for the favour, so if I demand more from the owner [i.e. being more difficult], they will simply refuse my request" (Nshimiye & Uwase, 4 June 2015). The owners are not entirely shielded from the risk of loss. Trustees may have a less than ideal production environment and often lack resources to supplement feed and pay for veterinary care. In other words, the animal's *productivity* is not the priority, but instead, it is its *life* and survival that matter the most.

Even with the best of intentions, an inappropriate livestock-in-kind arrangement may put the trustees at risk. Iribagiza is a widow and has no access to farmland. Without a farm or livestock, she trades crops for a living. Two years ago, the village *Girinka* committee chose her as the recipient of a *Girinka* pass-on. At the time of the village consultation, the local leaders asked if she would accept the next pass-on regardless of the gender of the calf. She agreed to the proposition, and in due time, she received a male calf. She hoped to sell it and buy a female calf, but Iribagiza faced a significant price disadvantage. While the price of selling her male calf would have brought about 70,000 RWF, a heifer of equivalent size would have cost at least 150,000 RWF (Iribagiza, May 2015). Furthermore, she would need to build a proper shed,

which would require more than 62,000 RWF (Pictures 6).⁵⁴ Iribagiza does not have the savings or means to cover these start-up costs. To compound her problems further, the lack of complementary assets such as land and family labour, and her irregular income stream, also raised, in relative terms, the *holding cost* and *security* concerns associated with the calf. It will most likely take her several more years before the investment in her *Girinka* cow will start to pay dividends.



Picture 6. Large and medium size cowsheds

Livestock ladder

Can one start from a single goat or a chicken and build toward a more substantial animal asset such as a cow? I asked the farmers who currently had no animals about this notion of a livestock ladder ($n_1=21$ and $n_2=21$ from Gisanza and Umuganura, respectively; see chapter 6). The farmers unanimously agreed that the logic of gradual livestock accumulation is strong, but, in practice, they found many reasons why the ladder approach would not work. First, it was necessary that the house and farmland were their own and they were not living and working solely on rental properties. Second, farmers had limited purchasing power to sustain the basic needs and lacked financial means to start the livestock development process. Other issues included the lack of labour and time often because they were too old or too busy in other work to look after animals.

Putting these issues aside for a moment, suppose that a farmer received a small animal. How long might it take to accumulate a more substantial portfolio of livestock assets? Farmers

⁵⁴ Iribagiza estimated the costs as follows: roofing (four corrugated metal sheets): $5,400 \times 4 = 22,600$ | wood beams (10 to 20): $2,000 \times (10 \text{ or } 20) = 20,000 \text{ or } 40,000$ | labour: 20,000 | Totalling 62,600 to 82,600 RWF (Iribagiza, May 2015).

forecasted that it would take on average 1.8 years to build up from a chicken to a goat (min. 4 months; max. 4 years). Similarly, they estimated four years to go from a goat to a cow (min. 1.5 years; max. 12 years). While the initial transfer of livestock can help the poor to reach the first rung of the ladder, they face relatively high costs which limit their productivity and profit. Also, they can face shocks and recurring expenses that could undermine the long-term accumulation plan. A farmer from Umuganura described the dilemma.

I think the idea of livestock ladder is feasible, but considering all the costs that would incur over the long periods of livestock development, it would end up costing the same as buying a cow. I prefer buying a cow now (by taking a loan) instead of going through the trouble of starting from chicken. (HH117, 3 March 2015)

The process of livestock accumulation rarely unfolds in a linear fashion, but instead, fluctuates in response to cyclical and sporadic household expenses and livelihood shocks. The type and number of livestock also reflect the household's priorities and use of animals.

Transferring of livestock allows the poor to gain access to livestock development. However, cows require constant care and resources, which low-income families have difficulties supplying. The *Girinka* and other international livestock transfer programmes try to address these gaps by providing long-term support to the beneficiaries. For instance, Send a Cow is one of the official partners of the *Girinka* programme. Their recipients go through a five-year-long process of training and support, with training covering topics such as water harvesting, animal health and feeding, soil fertility management and compost making, as well as, financial management, family conflict resolution and family planning. Send a Cow measures their beneficiaries' success in terms of well-being including food security, access to and attainment of education, health, ownership of household assets, and savings. The programme graduation criteria also include other intangible aspects such as the extent of women's roles in decision-making and their power at the household- and community-level, viable livelihood other than farming, and the beneficiaries' leadership and influence in their community. Their comprehensive approach tries to equip the graduating beneficiaries with both the means and concrete plans for the future (Interview at Send a Cow, 16 June 2015).

While the Send a Cow model prepares their beneficiaries thoroughly and comprehensively, the five-year commitment of training support and regular monitoring are expensive and labour intensive, while budget constraints limit the expansion of the programme. Since 2001, Send a Cow managed to graduate 3,700 beneficiaries. In comparison, the publicly funded *Girinka* programme (administered by the Ministry of Agriculture and Animal Resources) is putting

more emphasis on reaching out to as many beneficiaries as possible. From 2006 to 2015, MINAGRI distributed over 200,000 cows (Interview at RAB, 16 June 2015). Unfortunately, the balance between the quality of the programme and the reach is challenging. Heifer International, another major international organisation and a partner of *Girinka* programme, tries to strike a practical balance between the quality and quantity. For instance, while Send a Cow selects beneficiaries who have access to at least one hectare of land, Heifer International accepts any family with access to at least 0.4 hectares (Heifer International, 23 June 2015). Heifer International also closely monitors the performance of their beneficiaries, but it only follows up for one year after the successful pass-on. The country manager of Heifer International explained that the *Girinka* programme is more than a simple livestock-transfer programme.

The *Girinka* programme has been successful in some ways. As a national policy, it enhanced social cohesion. It brought the government and its people closer, and it built a stronger sense of community amongst the beneficiaries through sharing of pass-on calves. The environmental benefits of the programme remain to be measured, but manure is necessary for proper soil fertility management in Rwanda. On the other hand, economic gains are more complicated to quantify. For example, much of the milk consumed at home could be seen as reducing the (immediate) financial benefits from a commercial perspective, but a healthier population will positively contribute to building a stronger and economically able society. Yes, there are testimonials from some beneficiaries who claim to have achieved tremendous economic success through *Girinka* programme. Yes, some people have been successful, but regarding the broader impact of the intervention, I wait for more data collection and rigorous empirical analysis before I can comment on the *Girinka*'s contribution to the people's economic livelihood. (Interview at Heifer International, 23 June 2015)

The contributions of the *Girinka* cow to the beneficiaries and their community are multifaceted. Measuring the impact of *Girinka* cow should not be limited to the number of cows distributed or the amount of milk produced alone. Also, transferring an asset to the poor is only one of the many variables that are involved in the asset-based development strategy. Training and the follow-up support may increase the chances of programme success (i.e. pass on) and the beneficiary's economic livelihood. But without a more explicit understanding of the family's livelihood objectives and the multiplicity of their livestock's attributes, it seems uncertain that the government's efforts will engender a higher level of integration or intensification.

Usually, our beneficiaries keep about two cows only. When they start to have enough savings (after meeting all the immediate and short-term household needs and expenses), they buy land. However, people rarely

specialise in dairy production and keep more than three cows. Well, some beneficiaries specialise in dairy, but they are few. (Interview at Send a Cow, 16 June 2015)

Transition from crop-livestock integration to dairy specialisation: lessons from the Kigabiro-MCC members

Dairy production is one of the most lucrative income generating activities for farmers in Rwamagana. Since 2011, the government invested in refrigerated milk collection centres in every sector in the country (a total of 416) to help develop a modern dairy industry (Interview at Heifer International, 23 June 2015). Having a reliable market to sell the milk year around can be tremendously helpful (and profitable) for farmers who typically face weather shocks, price uncertainty and crop failures (Herrero et al. 2013). Also, milk is an essential source of fat in the local diet, and people consume it throughout the day as tea, porridge and sour yoghurt. Therefore, it is no surprise that farmers from Gisanza and Umuganura prioritised milk production (chapter 6). However, it is likely that the growing demand and policy support in dairy marketing will influence the extent and form of smallholders' crop-livestock integration. One possibility is the transition from crop-livestock integration to specialised dairy production. This shift can be regarded as an example of the final stage of the evolution of crop-livestock integration (McIntire et al. 1992). The current policy push for the dairy, and the crop intensification and land consolidation programmes, may incentivise some farmers to specialise (GoR 2011c, 2012b, 2013a). If such a transition is indeed taking place, then, what are the implications for smallholders and their livelihood? Kigabiro-MCC members provide an opportunity to study this phenomenon (**Appendix 8**). Two dominant production models can be identified.

Quality over quantity: genetic upgrading and downsizing strategy

Some farmers deliberately reduced the size of their herd in order to upgrade the quality of the stock, for example by cross-breeding local *Ankole* with exotic Jersey or Friesian cows. For instance, Murangwa used to have 30 *Ankole* cows. Since 1998, he began cross-breeding, and by 2015, he had reduced the herd number to eight (Murangwa, 19 March 2015). He plans to reduce the number even further.

I want to reduce the number of cows. I don't have enough land for feeding the cows. Naturally, if you give more and better feed, you can expect more milk. I want to reduce the number of cows to devote more feed and energy on fewer but more productive cows. (Murangwa, 19 March 2015)

Murangwa estimates that a hectare of forage grass is needed to feed one cow. Currently, he dedicates 2.5 hectares for grass production and another 2.5 hectares for crops. Along with the

fresh forage, he feeds maize bran and other crop residues such as maize and sorghum stover.⁵⁵ The extent of manure application is limited to maize production only. He hires three permanent cowherds to take care of his cows. In addition to the cut-and carry, Murangwa also has some pasture (Murangwa, 19 March 2015). What is surprising from his account is that despite the ample area and possession of all the productive resources, he struggles to feed his cows. He believes that the production will improve if their number is reduced. However, he is aware that they have limited genetic potential. When asked if he considered shifting to a pure dairy breed, he explained that the increase in milk yield would be marginal. “The differences in local climate conditions and production environment can work against the pure breeds. For example, Musoni’s [a neighbour’s] pure breed cow is worth over 2.5 million RWF, but he only gets four litres of milk a day” (Murangwa, 19 March 2015).

At the time of the interview, five of Murangwa’s cows were lactating and each was producing about six litres of milk per day. His remark about his neighbour’s cow reflects the logic of downsizing. That is, while genetic improvement would have a significant influence on performance in an ideal production environment, in practice, the better management would contribute more to overall performance than genetic improvement. There are some drawbacks to this strategy, however. Firstly, the implicit assumption is that the cow will successfully conceive and deliver and that there will be a sufficient amount of milk for sale. On the latter point, there will be a considerable demand for consumption for the families with younger children and those who decide to expand the herd or have to nurse pass-on calves. Secondly, under the zero grazing regime, the cost of herd expansion increases arithmetically. For example, if a farmer with one cow decides to rear a second one, the additional costs will double in every aspect of production including shelter, feeding, labour and veterinary care. Usabuwera’s life story and his experience with one-cow production reflect these issues.

Quantity over quality: intensification through economy of scale

Usabuwera is a project leader with an international aid agency in Rwamagana. Two years ago, on the occasion of his bachelor’s degree graduation, a group of friends bought him a local *Ankole* as a graduation gift. Usabuwera lives near the town in the peri-urban zone, and does not own any farmland. He built a shed and kept the cow in the back of the house. He also hired a permanent worker to take care of the cow. A year later, Usabuwera decided to buy a second cow and breed them so that milk production could continue throughout the year. However,

⁵⁵ See **glossary** for the meaning of stover.

the cost of production doubled – as he had to build another shed, hire a second labourer and buy double the amount of feed. He pays 15,000 RWF a month per labourer, and he also provides lodging and food for them. Usabuwera soon realised that two-cow production under the zero-grazing system is not economical and labour efficient. That is, under a pasturing system, the same two labourers could efficiently manage over ten cows. Taking his high salary and job security as collateral, he borrowed from the bank and purchased two plots (five hectares in total). He also bought more cows. Within two years, he transformed the small-scale zero grazing operation into a large-scale pasture operation with over 20 cross-breed and pure Jersey cows (Usabuwera, 13 March 2015).

On average, the herd produces about 50 to 60 litres of milk a day, which is equivalent to at least 1,000 litres of milk a month (Usabuwera, 25 May 2015). Taking into account the cost of transportation and the milk price received at the MCC, Usabuwera's milk revenue totals 200,000 RWF per month.⁵⁶ On the other hand, his total variable costs of production are 120,000 RWF per month. Therefore, even with the pessimistic milk production scenario, Usabuwera can expect over 80,000 RWF a month. To be precise, the fixed cost of land use in the form of mortgage payments should also be taken into account to reflect the real value of feeding. However, the land mortgage is no longer an issue for Usabuwera as he managed to pay back the loans very quickly by channelling his high salary and other income sources to pay the debt.

The transition from one-cow to specialised dairy production represents a complete departure from crop-livestock integration. Nonetheless, Usabuwera's case proves a point: dairy intensification through pasture grazing can have an economy of scale advantage over zero grazing. This point relates to the question of affordability that we saw in the earlier section. That is, there is a severe cost implication for intensification and expansion of dairy production under zero grazing. Therefore, the pasture grazing system is more economical and profitable for producers who have (and can afford) ten or more cows. However, the pathway of intensification through pasture grazing is only possible for a selective group of relatively wealthy people. These people are, strictly speaking, not farmers. Instead, they are agribusiness entrepreneurs and investors who can take advantage of their secure jobs and stable

⁵⁶ The milk cooperative buys milk at 225 RWF per litre, but with the subtraction of 25 RWF per litre for the transportation cost, Usabuwera earns 200 RWF per litre of milk (Usabuwera, 25 May 2015).

income flows and who can mobilise capital for investment in specialised dairy or crop production.

Conclusion

A conjuncture of life circumstances and crises shape and change people's livelihood. Life histories of the farmers captured some of these dynamics and serve to illustrate how family priorities and strategies develop across time and in response to pivotal life events. Farmers' engagement in crop and livestock farming and the resulting degree of integration depend on many factors. These life stories of the integrators highlighted a number of characteristics that shaped short- and long-term outcomes. First, harmonious working relationships and coordination between husband and wife provided a consistent level of high-quality labour, which served as the backbone of a successful crop-livestock integration. Second, with proper capital investment, farmers achieved land expansion and production intensification quickly and profitably. One's willingness to bear risk (often through taking on loans) varied individually. The family's aversion to loss weighed more when the family was young and had a higher dependency ratio.

The high cost of zero grazing makes expansion and intensification of production too expensive for many farmers, and effectively limits the number of cows they can keep to one or two. In other instances, *productivity* was not a priority. For example, one-cow production served as a kind of pension plan for an older farmer. The cow's milk and manure was sufficient for the household and for some for cash sales, but beyond that, the family did not pursue higher production. In other cases, families who had other sources of income besides farming kept a minimum amount of livestock and crops for home consumption. These families had no interest in intensifying or further investing in agriculture. Furthermore, the extent of integration also depended on the multiplicity of asset functions and interconnectedness of asset attributes. For instance, domestic animals play multiple roles in rural livelihood strategies, and sometimes, this can lead to competition in resource allocation. Thus, depending on the households' livelihood priority, different patterns of crop-livestock integration would emerge.

Farmland, housing, labour, cultivation of crops and forage grass and livestock are the fundamental components that make an integrated farming possible. The families who had no animals lacked many (or all) of these assets. Chief amongst these assets is housing – without it, there is no possibility of rearing any, not even the smallest, animal. Provision of start-up assets and securing the right to access them (especially land) can potentially help broaden the access

to a crop-livestock integration strategy. However, having access to or just owning these assets does not necessarily guarantee integration. Beyond the initial asset transfer, a long-term commitment to agricultural training and extension support needs to follow in order to safeguard the fragile production environment and to protect some level of asset accumulation for the poor.

The lessons from the members of the Kigabiro-MCC brought to light two pathways of dairy specialisation. Under a zero grazing regime, the high cost of production compels the farmers to produce more, using fewer resources. The combination of downsizing and genetic improvement of the herd addresses this imperative. The other pathway leaves crop-livestock integration behind. The transition from zero grazing to a pasture-based system leads to specialised dairy production. The economy of scale of pasture grazing captures a much higher margin of profit than zero grazing production, but the transition requires a capital investment that few can afford. In other words, while dairy specialisation is possible for the rich, for the majority of farmers, zero grazing is the only way that they can afford to keep and integrate one or two cows, at best, with crop farming.

Chapter 8 – Synthesis of findings and discussion

Amasho!

(I wish you many cows!)

Amashyongore!

(In reply: Likewise, and I wish you many spears to protect them!)

- A traditional greeting in Rwanda

A quick recall of the overarching research question will help establish the research aim, scope and main lines of argument of the thesis. The central research question was “How does the integration between crop and livestock production contribute to agricultural intensification for smallholders in Rwanda?” In this chapter, research findings are summarised and discussed along six sub-questions, and this is followed by a conclusion that reflects upon the theoretical, methodological and empirical contributions of this thesis, as well as its contribution to broader debates about development. I conclude by identifying potential areas for future research.

How have agriculture and rural development policies developed and changed in Rwanda; and what are the elements of continuity and change in the policy framing and narratives?

The main argument developed in this thesis was that there is a critical disjuncture between the government’s vision of modern agriculture based on increasing levels of intensification and commercialisation, and the ability of many smallholders to engage with this agenda. To substantiate this argument, in chapter 5, I used archival material to analyse elements of continuity and change in the policy framing and narratives of the crop-livestock integration agenda within which the tension between the government’s vision of agriculture and the farmers’ livelihood strategies and realities coincide. The analysis of previous agricultural and rural development strategies and policies revealed that there is an important element of continuity running through the policies that are being promoted today.

Given the central role of the agriculture sector in the country’s economy and development, the modernisation and rapid transformation of agriculture production systems have been the fundamental objectives of rural development policies in Rwanda since Independence in 1962. Successive governments developed various plans and interventions to tackle the farm productivity problem, of which some were more successful than others (Table 7, p.73). The overarching policy objective was to increase production by expansion of arable land and improving yields per unit of area. Despite the long-held policy narrative that made ‘paucity of arable land’ the leading cause of the Rwandan agriculture problem, up until 2000s, most

production increases resulted from the land expansion policy. At the same time, governments have repeatedly argued that given Rwanda's geographic and environmental conditions, the potential for expansion is limited, and therefore, achieving higher land productivity through the intensive use of modern inputs was critical.

Despite the long-standing plan for 'modernisation' and transformation of the agriculture sector, however, the adoption of intensive production practices by smallholder farmers remain limited. Historically, only a small number of farmers followed this path, with only those who participated in subsidised programmes applying inputs such as fertiliser, improved seeds and herbicides. The agriculture inputs that these intensive production methods require are dependent on a host of infrastructure, market channels and value chains to which many people in the rural areas simply did not have access.

Another route to intensification that has been promoted over the years is crop and livestock integration. By integrating the outputs from one enterprise into another, smallholders can harness the benefits of nutrient recycling and feed production. This policy had a certain logic because many of the farmers had livestock including chickens, goats, and cattle. But amongst them all, the dairy cow has been considered the most valuable for integrated farming. The reasons for this are two-fold. First, cattle manure is the most widely used soil amendment in Rwanda. While some farmers use the dung of small animals, the difficulty in collecting it limits its use. Second, forage production and crop residue feeding complete the nutrient recycling loop that links crop and livestock production.

The integration agenda became more urgent with the uncertainty and volatility in global commodity market prices and the episodic crop failures in the 1980s. The government branded the integration strategy as being a practical solution appropriate for Rwandan farming conditions and encouraged production and application of organic fertiliser for soil conservation and improving soil fertility. However, despite the universal need of livestock for manure and soil amendments, only about quarter of the population owned cattle. The government provided no further policy measures, recommendations or actions to increase the access to livestock.

In other instances, trying to solve one issue created other unintended problems. For example, the land expansion policy had a counter effect on the productivity-led intensification agenda. Previously uncultivated marshlands and steep hillsides became available for farming, but also, much of the pasture and grazing land came under cultivation. The closure of pasture land had

a direct negative impact on livestock feed availability. The lack of affordable feed further reduced the farmers' ability to rear cattle. The number of cattle gradually decreased from the late 1960s to 1990s, while small livestock numbers increased.

In response, the government encouraged (and later enforced) alternative feeding practices such as semi- and zero grazing and contour grass strip production to compensate for the loss of grazing land. While these methods sought to increase the overall forage production capacity of smallholders, they raised rearing costs. Farmers now had to cut and carry fresh grass and fetch water daily. The in-stall feeding and rearing also required adequate spacing and housing. Frequent cleaning and removal of excreta added to the labour costs. Moreover, the distance from the animal shed to the farm plots meant that manure had to be stored, composted, and transported. Farmers also had to learn about animal health and hygiene, and manure management under zero grazing. The government offered technical training, but the number of farmers far outweighed the capacity and the resources allocated for extension services. The combined effect of all these added costs and lack of adequate support undermined smallholders' productivity, especially for those with a limited asset base, in particular having little land and a shortage of family labour. Zero grazing is the most widely practised feeding regime in Rwanda today, and these problems persist in rural areas.

Also, all previous governments relied on technological upgrading, institutional control over access to land and labour resources, and more recently, the state's direct engagement in the market, which were all inspired by a long history of technical solution-based policy framing in Rwanda. The concern raised here is that the government's policy framing and narratives reduced fundamentally social and cultural issues of rural development to technical details. An example of such policy that was directly opposed to the efforts of increasing manure production was the government's decision to invest in modernising the dairy sector and genetic upgrading of cattle breeds. In this case, the government narrowly prioritised a particular aspect of production; that of milk, over other production functions and services. This severely compromised farmers' capacity and incentive for integration. Thus, the overall decline in cattle number resulted in a cut-back of manure supply.

There have also been substantial changes brought in by the new administration. The current government introduced the Crop Intensification Programme and Land Use Consolidation policy in the mid-2000s to collectivise small and fragmented plots into a large-scale farm suitable for monocropping. Large-scale production can better achieve input efficiency and the economies

of scale than smaller farms. Since the implementation of the programmes in 2007, crop production increased substantially at the national level.

Similarly, the livestock sector development policy has seen a significant change since the RPF government came into power. After the genocide, the government stepped in to accelerate the restocking of animals through artificial insemination and livestock transfer programmes. Farmers were encouraged to replace local breeds with more productive dairy cows to prioritise modern dairy sector development. Given the land constraints for livestock feed production, intensive (i.e. zero grazing) milk production is considered by government to be the most economically viable option for the small-scale producers.

The *Girinka*, or One cow per poor family, is the flagship of the government's asset transfer programme, which aims to distribute a dairy cow to every low-income household in rural areas. Ultimately, the plan is to reduce the unequal distribution of cattle ownership and broaden the access to dairy and manure production for those without the means to purchase cattle.

The government's appreciation for the farmers' contribution to national food security changed drastically from the previous to the incumbent administration. The positive depiction of 'prosperous rural life' once held by the previous governments is no longer reflected in the current government's Vision 2020. Instead, existing agriculture is labelled as 'unproductive' such that smallholders 'can no longer subsist on land'. What is clear from the current views on agricultural development is that subsistence-oriented farming is considered obsolete. The government is determined to bring the 'peasantry' to an end and in its place, establish a new order in the rural economy and agriculture sector: aiming to transform it into a modern commercial agriculture.

What lessons can be drawn from the evolution of agricultural policies that are relevant to the current vision of rural development and the politics of agricultural policies in Rwanda today?

In chapter 2, the issue of increasing population and pressure on land for growing food was discussed in line with the debate on whether the Rwandan economy and demography were caught in the so-called 'Malthusian trap'. It is easy to dismiss the Malthusian argument with the simple fact that today, more people are living in Rwanda than ever before and that there is no imminent threat of famine nor massive food shortages. What is hard to disapprove, however, is the premise of the neo-Malthusian argument that the issues of decreasing arable land size per household and poor crop productivity will eventually lead to disaster. With the

majority of the population still relying on farming today, the social and political expectations are high for the government to develop and intensify agriculture.

There are two (competing) forces that motivated the agriculture policy agenda over the years. They are household food security (self-sufficiency) and commercial production (surplus). While the former is directly relevant to the people, the latter is mainly instigated by the government. With population growth outpacing farm productivity, a deep-seated conflict of interests between the government and farmers arose at times which took the form of over-reliance on export crops and underinvestment in staple crops. However, both the government and the people had a common problem of low agricultural productivity to solve. While fundamentally, there are social and political issues that were at the heart of the productivity problem, the government considered the farmers' low interest and (human) capacity to engage in commercial production as being primarily responsible for the lack of agricultural development.

The government's logic of agricultural development closely resembles and follows the 'evolutionary' approach. The combination of rapidly rising population density and decreasing smallholder production capacity was the main impetus behind the government's policy thinking. At the theoretical level, the concept of integrated crop-livestock systems and the Boserup's stages of agricultural growth merged to become the general model of the evolution of crop-livestock interactions (McIntire et al. 1992). The model posits seven stages for the crop and livestock interactions where the integration of crop-livestock farming serves as an intermediate step between the subsistence-based production and the intensive, specialised production system.

Although the evolutionary model of agriculture development offers a sense of order and distinct stages of development for the government to prioritise, the government's singular and, some would argue, linear vision of intensification and transformation of agriculture diverted the policy debate away from the core issues of access to land, overpopulation and undiversified economy. Instead, the government shifted the burden of production and economic development to the farmers. Despite the widely variable conditions that smallholder farmers work in, current policy is directed towards improving yields by land consolidation and monocropping, and investing in specialised dairy production. The government argues that low productivity can be overcome through an effective coordination between the state and agro-industries, and investment in commercial value chains under the aegis of the public-private-partnerships. Indeed, the government proved that higher yields could be achieved by subsidising and supplying inputs to farmers participating in large land consolidation projects.

While some observers applaud the success in sustaining economic growth and commercial development of the agriculture sector, others warn that the current policy agenda is not in alignment with the rural reality and does little to address the underlying issues of undiversified rural livelihoods. While agricultural intensification may be a shared objective for both the government and smallholders, the gap between the intensification methods and modalities that the state envisions and the farmers' capacity to implement them is large. Moreover, agrarian transformation in Rwanda will not be complete unless the government understands and addresses the underlying social and political forces that motivate farmers to engage (or not) with the government's vision of modern agriculture.

What are the patterns of crop-livestock interactions and their contributions to both livelihood activities and soil fertility and animal feed management?

Depending on the type and degree of integration, crop-livestock integration can take varying forms. Three parameters were central to the analysis of the extent and the patterns of crop and livestock integration. The first is the use and importance of animal excreta as a soil amendment. The second is the sourcing of animal feed and the use and importance of crop residue as feed. The third is the role of animals as functional livelihood assets. The extent of crop and livestock integration varied between the rural and peri-urban sites and the household's wealth categories.

The use and importance of animal excreta

The use of organic manure, primarily from cattle, was a prominent feature of integration activity in Gisanza. All households with cows, regardless of their wealth categories, used it. Manure production and management practices varied considerably amongst the families, but many faced challenges in sourcing a sufficient quantity of manure year-around. Farmers had several options to remedy the gap. Those who could afford it (mainly the non-poor) purchased manure from neighbours. Others, especially the poor and some of the middle group households, retrieved manure from small livestock, which is considerably more laborious.

Similarly, organic manure is also in demand in Umuganura. However, despite having access to more land and livestock, the rich used less manure than others. Interestingly, the poor used more chemical fertiliser than the rich, which seems to indicate the higher importance and relevance of investment in farming for the poor. In the peri-urban location, investment in crop-livestock integration vies with other competing economic opportunities. In other words, higher proportions of the wealthier family members and their head of household worked in non-

farming jobs than the poor. From the soil fertility management standpoint, the differences between the poor, middle and rich groups of farmers were insignificant.

Sourcing of animal feed and the use of crop residues as feed

Forage production and crop residue are essential components of feed management in both study sites. Nearly every livestock-owning farmer grew grass on the contours of the plots. However, the majority of livestock owners could not produce sufficient grass year-around. Two factors restrict the expansion and intensification of grass production. Firstly, because farmers continually cultivate their land, there is little space available for grass production. Secondly, farmers do not irrigate, and therefore, both crop and grass cultivation are subject to seasonal cycles of water availability. The lack of water severely affects grass production during the dry season in Rwamagana.

To make up the shortage of own grass production, farmers either buy grass from neighbours or forage from surrounding areas. Clear distinctions appear in the feeding strategies adopted by the poor and the rich. The majority of the wealthier farmers purchased grass from neighbours and commercial feed such as maize and rice bran. On the other hand, most of the poor and middle groups who could not afford to buy relied on wayside grass and crop residue. Although these foraged weeds and crop by-products are of limited nutritional value, they allow smallholders who have no means to purchase additional feed to maintain their livestock through lean periods. None of the surveyed farmers treated the crop residues to balance the nutrients or to improve palatability.

The distinctive feature of local feeding practices and strategies amongst the poor and rich crop-livestock producers emerged from two conditions. The first results from the family's purchasing power. Poor farmers have little disposable income and economic security to invest in feed. Therefore, the financial risk of intensive dairy production is much higher for the poor farmers. The second condition arises from local feeding practice that is specific to the type of livestock and the market conditions. Farmers only fed purchased grass to cows and not small ruminants. Currently, feeding small ruminants with purchased feed is not financially viable in Rwamagana.

Multi-functionality and asset attributes of livestock

A belief in progressive asset accumulation and the use of cattle within asset-based development programmes is widely held. Although the significance of livestock in rural

livelihood strategies features prominently in the literature, the concepts such as 'livestock-based asset development' and 'livestock ladder' still lack empirical validation. In this thesis, I introduced Dorward et al.'s (2001) asset functions framework and advanced the notion of livestock as assets with various attributes that fulfil multiple livelihood functions within small-scale farm productions (Kim and Sumberg 2015). Different animals play different roles in resource-restrained production conditions.

Regardless of their wealth status, milk and manure production ranked as top priority functions for all cattle owners in Gisanza. No one reared cattle for meat. Significantly more low-income families prioritised growing the herd size (reproduction) than the other wealth groups. Cattle played a much less significant role as savings such as arising from cashing in from offspring sales, for the poor than for the rich. This observation implies that if the wealthy families have achieved the desired number of cattle, then they are more likely to sell the offspring for cash. Correspondingly, many of the poor smallholders were still in the process of growing their herd, and thus, did not want to sell their animals yet.

In Umuganura, dairy production was the top activity of cattle owners. While milk production ranks high for all cattle owners, the average milk production is significantly higher for the wealthier families compared to the others, which reflects more significant investment in feed and reproduction management. The majority of farmers kept only one cow. There are economic and agronomic reasons behind the predominance of one-cow production in Umuganura. Farmers in the peri-urban village have less access to arable land and rely heavily on the purchased feed from outside their farm to supplement the animal feed. The high cost of commercial feed was a barrier to expansion and intensification of livestock production. In the case of peri-urban settings, a cow's utility as a savings account was less appealing to the rich because they have access to financial institutions and commercial banks.

The extent of integration between small animals and crop production was weak in both study sites. Many of the poor farmers used their manure, but inadequate investment in a proper shed and poor quality of feed limited the potential for intensification and integration. Goats and chickens were, above all else, for family consumption and savings. On the other hand, cattle and cropping were intricately linked and integrated. For crop-livestock farmers who had cows, both dairy and manure production were integral components of their livelihood.

In sum, I found considerable crop and livestock integration through soil fertility and animal feed management in the study sites. The extent of integration and its implications for other

livelihood functions varied between different groups of farmers. Moreover, by looking at multiple functionalities and livelihood utilities that livestock represented for various farmers, the comparative assessment demonstrated different patterns and levels of engagement in crop and livestock integration activities amongst the economically-stratified groups. The findings from the comparative analysis also indicated that while integration of farming and dairy production presented a viable economic opportunity to some, it may pose a great risk to the economically vulnerable and poorly resourced households.

Finally, despite the widespread assumption that the crop-livestock integration is accessible and would be beneficial to the majority of smallholder farmers in Rwanda, the household survey and life history interviews of the farmers revealed that one in four households could not afford to engage in crop-livestock production as there was no integration. There were significant issues that barred the development of their livelihoods. The factors that affect the propensity for crop-livestock integration by smallholders are discussed in more detail under the next question.

What are the pathways or trajectories that led to the observed patterns of engagement with livestock?

In chapter 7, I argued that pathways of agricultural intensification and crop-livestock integration are highly contingent on agro-ecological and socio-economic conditions, but they are also shaped and affected by the multiplicity of functions and characteristics attributed to livestock as assets. I adapted Dorward et al.'s asset functions framework (2001), which encompasses nine asset attributes to unpack the underlying determinants that differentiate the propensity for crop-livestock integration of farmers from the different economic backgrounds. The asset attributes include life, productivity, utility, holding cost, security, social relations, ownership and control, convertibility, and complementarity. Three forms or levels of integration were observed.

High integration

The extent of integration depended on the multiplicity of livestock functions and the interconnectedness of asset attributes. In chapters 6 and 7, various asset attributes explained how farmers from different economic backgrounds valued animals according to their livelihood context and priorities. Different patterns of crop-livestock integration reflect current differences in wealth and cattle ownership, but these are not conditioned directly by parents' wealth and past experiences with livestock. The lack of security and episodes of violent conflict and pillage repeatedly eroded the family's asset holding, particularly livestock, which

negatively affected nearly all the interviewed households. However, what sets the high crop-livestock integrators apart from the rest is their resilience and ability to recover from the loss quickly.

What was most remarkable from the post-conflict experiences of the high integrators is their varying ability to recover their house and family land. Families and neighbours' social and financial support was instrumental in rebuilding their lost assets. With the security of having their own property and farmland to cultivate both staple and cash crops, these farmers were able to purchase and rear livestock successfully. Resilience is also associated with a harmonious and complementary working relationship between husband and wife as the backbone of a successful crop-livestock integration. Consistency in feeding, milking and caring work is particularly vital for ensuring healthy and profitable dairy and manure production.

A drive for self-improvement and willingness to experiment with new production methods were distinct characteristics of the resilience of the high integrators. Another critical ingredient was capital investment. The remarkable example of land expansion and production intensification of one of the integrators illustrates what some rural entrepreneurs can achieve with proper financial resources. A person's tolerance for risk, however, varies individually and the family's aversion to loss would be much higher in the case when the family has many dependents.

Low integration

Farmers whose crop and livestock production are not closely integrated came from a range of economic backgrounds. Many of the economically disadvantaged families cited the high costs of zero grazing (and in-stall rearing) as the leading cause of low integration. Regardless of the economic background, nearly all low integrators faced feed shortages during the dry season, and many could not afford to buy fresh grass and feed supplements. Rearing a big animal in a confined space obliges farmers to commit a constant level of care day in day out, which is both time-consuming and labour-intensive work even if it is just one cow.

For some farmers, crop-livestock expansion and achieving higher productivity were not prioritised. For example, an elderly farmer managed a low integration, one-cow production system as a kind of 'pension plan'. In other instances, aspirations for professional work and an interest in other forms of business reduced the families' interests in agriculture. Moreover, income from other jobs reduced the dependency on farming. However, these wealthy families

continued to keep some cows and cultivate plots. Satisfying food consumption needs is their primary reason for crop-livestock integration, and not the intensification, for these families.

Similarly, when younger generations moved away from family farming, the ties between crop and livestock productions were less tenable. For these families, the older farmers wanted to keep the family farm, for the sake of long-held values. It is worth highlighting that these families had no intention of intensifying or further investing in agriculture in spite of their productive asset holdings and financial capacity.

In other instances, families who are engaging in low levels of crop and livestock integration may not be able to intensify due to economic and socio-cultural issues. In the rural context in Rwanda, the passage to adulthood triggers the transfer of productive assets such as land and cow or money to build a house from the older generation to the younger. Some of the interviewed families reported the difficulty of managing the expectations of these social relations and keeping the momentum of asset accumulation when successive children claimed support for their start-up or allocation of (advance) inheritance.

No integration

Lack of basic resources and assets to earn a decent living through farming was the leading cause of no integration. Poor farmers stressed the importance of having secured their own housing and having access to farmland and livestock as pre-requirements for integration. The loss of access and right to work on family land was another major issue for the recently migrated families in the villages. Land conflict is still rife in rural areas in Rwanda. Family feuds could lead to long and ongoing legal cases, delays in compensation and lost development opportunities. In a smallholder context, without the ownership and control of housing and land, none of the other productive assets such as labour and livestock could be utilised.

In other cases, a chain of unexpected events and misfortunes wiped out the progress and gains made in one's lifetime in overnight. The examples of significant livelihood shocks and crises experienced by the interviewed farmers reinforce the need for the provision of essential access to livelihood opportunities and transfer of start-up assets to relieve the families who have no means to recuperate and restart the development process. For farmers who have not yet secured their own housing and who have no regular income, all financial decisions revolved around paying the monthly rent. When nearly all the earnings go to rent and food, it is impossible to save or invest in livestock. In principle, livestock-in-kind or in-trust contracts such

as *Girinka* cows or an *indagizanyo* arrangement for a small animal can be a relief for families who have no means to save or accumulate livestock assets. Bearing in mind that about a quarter of the sampled households in the two villages had no livestock, the livestock-in-kind or in-trust arrangements could potentially strengthen the livestock-livelihood linkages that would enable more low-income families to engage in crop-livestock production.

What does the experience of promoting crop-livestock integration tell us about livestock asset transfer programmes and livestock-in-kind development strategies in Rwanda?

The practice of *indagizanyo*, a livestock-in-trust or loaning scheme, was common in the region. Typically, an *indagizanyo* contract brings together a willing lender of an animal and a trustee who promises to keep and rear it until it delivers several (at least two) rounds of healthy offspring to share between the two parties (pass on). In the case of the *Girinka* programme, the lender is the government (MINAGRI and through NGO partners), and the beneficiaries are rural families who fall under specific eligibility criteria. These criteria vary substantially depending on the NGOs and the government's targeting standards. However, the underlying principle (assumption) of these livestock-based asset development strategies is the same. Simply put, the expectation is that with some extension training and support and donation of a farm animal, poor households could start building a more substantial herd. This logic of progressive livestock accumulation forms the basis of the notion of a livestock ladder.

In theory, the livestock-in-kind contract could potentially offer a win-win scenario for both parties while spreading the risk and costs of livestock production. In practice, however, the informal arrangements often fall through due to premature death and infertility, with both parties assuming the loss. Moreover, an inappropriate livestock-in-kind arrangement can put the trustees at higher risk. Careful understanding and correct assessment of the recipient's production capacity and livelihood options are essential for the success of livestock transfer programmes.

The farmers unanimously agreed that the logic of gradual livestock accumulation is convincing, but in reality, they found many issues that would delay the progression of ladder approach. Often, the poor have fewer resources to invest in supplementary feeding, proper shed and veterinary care – all of which matter for a healthy reproduction cycle. Also, if the animal is from a livestock-in-kind arrangement, farmers would not prioritise the animal's productivity, at least not during the initial growth and delivery phase of the contract. Instead, it is an animal's life and its survival that would matter the most. With these production conditions and factors

in mind, the farmers estimated that starting from a single chicken and moving to a goat could take on average almost two years, and from a goat to a cow four years.

The farmers' outlook on the livestock-based asset development stands in stark contrast to the logic of the livestock development for the poor. While the initial transfer of livestock may lift the poor to the first rung of the livestock ladder, it is still unclear how the poor will generate surplus and progress into their development. It is hard to agree that the poor will automatically manage and lift themselves out of their low production environment and conditions. In fact, even with the asset transfer, many of the recipients will face a challenging production environment with limited prospects of generating profit. The process of livestock accumulation rarely unfolds linearly. Instead, it fluctuates in response to cyclical and sporadic household expenses and livelihood shocks, which could undermine the long-term accumulation plan.

What is the evidence base supporting intensification through mixed crop-livestock farming as a viable option for the smallholders in Rwanda; if so, for whom, and in what circumstances is intensification through crop and livestock integration a potential pathway out of poverty?

The combined conceptual framework of livelihood aspirations and strategies of the poor (Dorward et al. 2009) and the life cycle dimension of the family farm cycle (Bourgeois and Sebillotte 1978) will guide the discussion about different pathways and dynamics of agricultural intensification, transformation and development for the smallholders. Three broad representations of livelihood strategy of the farmers and their corresponding uses of assets and their engagement in economic activities elucidate how mixed crop-livestock farming contributes (or not) to intensification.

‘Stepping up’ through mixed crop-livestock farming

The experiences of highly integrated farmers in Gisanza represent the potential case of agriculture intensification pathway through integration. The asset holdings that are essential to farming – land, labour and livestock – positively correlated with their wealth standing. Dairy production and sales of offspring allowed the high crop-livestock integrators to save and invest back in agriculture. These farmers effectively managed to grow and accumulate assets from their intensive production and planned to expand gradually through purchasing land.

The crop-livestock producers diversified their crop and fodder cultivation. The diversity of products grown on multiple plots revealed how important diversification strategy is for these farmers who are under pressure to produce more crops and fodder in fragmented areas. Given

the current production and market conditions, the crop-livestock integrators chose to optimise their production through intercropping. However, an intercropping strategy stands against the government's plan to consolidate and intensify production. At the moment, the local government is only enforcing their monocropping policy in the Land Consolidation programme areas. However, these areas are expected to grow more widely, which will put more integrated farmlands under their monitoring and control.

Regarding soil fertility management, all cattle farmers used manure, but the number of households using chemical fertiliser was minimal even amongst the wealthy farmers. The average reported amounts of chemical fertiliser used are below the government recommendation. Although the number of farmers using chemical fertiliser is rising in Rwanda today, organic manure will continue to be the primary source of soil fertility amendments for the foreseeable future. However, given the shortage of animal manure and the small amount of chemical fertiliser application, concern has been raised on the long-term effect on soil fertility and its ramification on crop and fodder yields. One way to boost the chance of 'stepping up' through the integration pathway, is to focus not only on the number of cows distributed but also on the quality of composted manure to ensure high return and retention of soil nutrients and organic matter back to the field. Addressing the physical challenge of carrying bulky manure long distances and to multiple locations must be considered.

There were also reasons to believe in the possibility of 'stepping up' from subsistence to commercial farming in Umuganura. The villagers have access to all the amenities and services such as veterinarian care and commercial agricultural inputs, as well as the well-functioning markets for crop and livestock products. However, farmers did not integrate crop and livestock production as suggested.

'Stepping out' from mixed crop-livestock farming

Farming was not the principal economic activity for the majority of non-poor families in Umuganura. In addition to family farming, the household members of these groups also had non-farm employment often in the form of casual jobs in town. With the growing and booming businesses in Rwamagana, the job opportunities in the urban centre offered a viable alternative for 'stepping out' of family farming. Therefore, in the peri-urban setting, the 'stepping out' of farming seems to indicate a potential pathway out of poverty. In the rural area, however, the off-farm work opportunities were almost non-existent. The undiversified

economic activities and reliance on farming limited the potential for 'stepping out' of farming in Gisanza.

Smallholders in the peri-urban village were more limited in their farming enterprise than their rural counterpart. The small parcels of land that the poor possess were not sufficient to sustain the family's needs, so many of them also sought casual farm labour work. However, these work opportunities are temporary and could only supplement the subsistence needs. The income from casual labour was not profitable enough to reduce reliance on farming. In this sense, without other viable alternatives outside of agriculture, most of the poor farmers could only manage "hanging in" through crop-livestock integration.

Some cases were on the verge of 'stepping out' depending on the priorities specific to the lifecycle stages of a family farm. For instance, professional couples with young children engaged in integrated farming solely for increasing their food and milk consumption. Their engagement with family farming will most likely phase out with the children's changing dietary priorities. On the other range, some families had no successor to take over the family farms. The younger generation moved out to the city (and some even abroad) and had no interest in the rural livelihoods of their parents'. The older generation kept farming and rearing cattle, but it is a matter of time until these family farms will cease to operate.

'Hanging in' to mixed crop-livestock farming

There is a growing demand and policy support for dairying in Rwanda. Dairy production is one of the most lucrative activities for farmers, and this is reflected in the priorities of farmers in Gisanza and Umuganura. There is a possibility that the growing demand and policy support in dairy and selective crop marketing will support a shift from integration to specialisation. For instance, some farmers from the cooperative milk centre in Kigabiro deliberately reduced the size of their herd to upgrade the quality of stock, with the hope of increasing its genetic capacity and productivity. While genetic improvement would have a significant influence on performance in an ideal production environment, in practice, better management would contribute more to overall performance than genetic improvement. For this reason, healthy reproduction and high milk yields mainly depended on there being a sufficient quantity and quality of animal feed and veterinary care.

Providing such a proper management and conducive production environment is, therefore, *the* issue for the crop-livestock producers. However, the high cost of integrated production under

the zero grazing regime was the main hurdle for the majority of farmers who kept only one to two cows. Without the means to purchase the commercial feeds and fodder grass, farmers had to resort to crop residues and wayside vegetation to supplement the animal diet. The low nutrient contents and poor digestibility of these types of feed limited commercial production. The potential for intensification through integration is unlikely for these farmers.

Implications for the policy of intensification through crop and livestock integration

There was a considerable variation in the crop-livestock integrators' factors of production including their aspiration and motivation as well as access to finance and assets. Diverse examples of crop-livestock producers indicated that there are severe limitations in intensification due to high costs associated with zero grazing practice. With the current shortage of forage grass and lack of affordable commercial animal feed, the zero grazing producers are economically constrained to expand beyond one to two cross-breed cows. The financial resource required for intensification was beyond the grasp of most of the crop-livestock producers. Without collateral or a steady and secure income, smallholders who depend solely on agriculture are most likely to be excluded from the commercial credit market. In the peri-urban context, different degrees of integration between livestock holding and crop cultivation manifested for the families who had other off-farm economic opportunities. For many of these financially better-off families, crop-livestock integration was not the primary livelihood strategy.

The pathway of intensification through crop and livestock integration was best suited for a specific segment of the rural population. The pathways leading to high productivity are capital intensive and technically specialised, which at the moment, only a relatively wealthy group of farmers can follow. The narrow focus on the crop and dairy integration as the ideal model to emulate regardless of the livelihood context overshadows other potentially important alternatives for smallholders. The diversity and complexity that arise from small-scale integrated production warrants more research and critical and nuanced assessment.

Failing to capture the differences in the strengths and weaknesses of different farmers will fail to bring a more inclusive agricultural development process in the rural areas. While these structural challenges are unaccounted for in policy framing, the government-sponsored asset transfer programmes such as Girinka target and distribute cows to economically vulnerable households. A dairy cow, inherently on its own, is neither a productive or non-productive asset. There are other attributes and supportive conditions such as land, labour, transportation

infrastructures, and reliable markets for dairy products, which make a cow something of value and worth keeping (and replicating). Handing out more cows to smallholder farmers will not solve the structural constraints of the shortage of land, lack of other work opportunities and the shortage of financial investment and resources in rural areas. Not surprisingly, these underlying limitations will continue to limit the smallholder producers to a low level of production. The traditional greeting that opened this chapter holds a fundamental lesson about livestock development in Rwanda. Owning a cow is only half the blessing. Without having the means to protect and sustain it, the full potential of crop and dairy production and commercialisation will remain unlocked for many smallholder crop-livestock farmers in Rwanda.

Conclusion

Theoretical contribution

This thesis critically examined issues concerning agricultural intensification and the role of smallholder farmers in Rwanda. In many ways, the agrarian development experience in Rwanda epitomised the broader sustainable intensification debate and question: notwithstanding that many African states envision agricultural transformation, how could a smallholder producer prioritise and strive for achieving the intensification and commercialisation agenda when their current means of production remains subsistence-based?

The concept of evolutionary crop-livestock integration dominated the policy thinking and responses to the land and population pressures in sub-Saharan Africa. According to this evolutionary view of agricultural change, an integrated crop and livestock production is an intermediate step to transition from extensive to more intensive systems moving from subsistence to market-oriented agriculture. However, despite continued efforts to transform agricultural and rural livelihoods through mixed farming, many farmers do not have the resources required to realise intensification through integrated crop-livestock production. This paradox brought to attention the need for a broader inquiry and improving the understanding of productivity in the smallholder farming context. In line with Scoones and Wolmer's thesis of multiple pathways (2002), this research investigated diversity and variability of people's aspiration, abilities, and production goals associated with livelihood contexts and livestock holding.

This thesis found that although the enhanced synergy from the crop-livestock integration could yield substantial benefits, the cases of successful integration were limited to a relatively small and well-off group within the rural population. The majority of the small-scale farmers pursued other marginal variants of integration, which had a low potential for intensification and commercialisation. Furthermore, this thesis identified various factors that inhibited expansion and intensification through crop-livestock integration for smallholders in rural and peri-urban areas. In sum, the research findings raised the problem of misplaced and unrealistic policy expectation of what crop-livestock integration should accomplish for small-scale farmers and the agriculture sector at large.

The development planners and policy makers in Rwanda considered livestock (especially cattle) to play a central role in agricultural intensification. By adopting Dorward et al.'s thinking

of the asset function framework, this study found different types of livestock fulfilling broader livelihood functions and roles other than agronomic purposes in resource-retrained production environments and livelihood contexts. The study findings challenge the cattle-centric livestock development agenda on the ground that the resource required to pursue cattle-based integration pathways are out of reach for most of the small-scale farmers. Instead, the research highlighted other ways in which resource-constrained groups of farmers engaged in various pathways of intensification using alternative animal feeds and soil fertility management techniques.

The crucial insight that emerged from this thesis is that while the current government's early success in increasing agricultural productivity and aggregate food security is recognised, the same government policies that rely on the linear transfer of technology approach are unlikely to bring about an inclusive agricultural transformation and commercialisation of smallholder farmers. Far from what the deterministic evolutionary theory of agriculture development suggests, farmers' production and livelihood priorities and strategies change continuously within dynamic context-specific settings. However, the complexity of the farming system does not mean that every farming context would require a unique policy or strategy. Despite the absence of policy support in small livestock and manure production, for instance, resource-constrained farmers continue to manage a risky but resilient livelihood production. It is in these areas - where farmers are already investing and engaging - that the government can step in to reduce risks, provide a targeted safety net and social protection programme to the vulnerable groups, and expand market networks through better physical infrastructure and more accessible information and technology. Therefore, the current government's approach to modernisation and transformation of agriculture, which requires high institutional compliance and a standardised production environment to deliver the technological interventions will continue to face challenges in Rwanda's highly differentiated rural and peri-urban areas.

Methodological and empirical contribution

In the literature, the complexity of agriculture and food systems pointed toward engaging in interdisciplinary inquiry including agroecology and political economy, as well as socio-ecological systems. An analytical framework that encompasses the market and non-market spheres of agriculture production was essential for this research. One of the most prominent analytical frameworks used to conceptualise agricultural intensification was that of farming systems. The farming systems model helped to understand the interrelationship between

various components and forces that linked the natural environment and the social institutions, which were crucial in addressing the research questions of the thesis.

The mixed-methods approach broadened the analytical scope that contextualises and situates the relative importance of livestock in farming and livelihood development at the household level. The combination of archival research, village studies through household surveys and life history analyses not only helped in the sequential design of the study but also complemented the data analysis and interpretation of the findings. The multiple and iterative phases of the different types of data collection allowed for more in-depth and contextual analysis than would have been possible through using just a single research method. As a result, a comprehensive fieldwork assessment of smallholder production systems presented in this study broadens the empirical knowledge for the less considered (and researched) production pathways and livelihood strategies that are suitable for small-scale farmers.

More specific to the empirical research in Rwanda, while the need for more methodological integration and interdisciplinarity in farming systems research has been acknowledged, the extensive field of analysis and the complexity involved in the mixed-methods framework have limited empirical contributions thus far. There has been little systematic and comprehensive research done to explain what crops and animals, in which spatial settings (urban versus rural), and for whom such intensification strategies may be beneficial in Rwanda. By integrating historical policy framings with the context-specific empirical data, both quantitative and qualitative, this thesis brought various types of findings together to provide a new perspective on agricultural intensification through crop and livestock integration.

Broader contribution to development debates and practice

This thesis engaged with broader debates about intensification and commercialisation of agriculture and the transformation of livelihoods of subsistence farmers in sub-Saharan Africa. The increasing and competing demands for food, water, and energy make agricultural intensification imperative for Africa. While intensification and commercialisation of both crop and livestock production are at the top of the agricultural agenda in many countries in Africa, the sustainable intensification agenda does not yet provide a clear answer as to how smallholder farmers can meet multiple livelihood demands sustainably. This thesis argued that the level of ambition for agricultural intensification and transformation is not matched by the ability of many smallholders to engage with this agenda. The research findings suggest that

this disjuncture poses a significant challenge for policy efforts to develop and improve the rural economy and thus the livelihoods of millions of small-scale producers.

Moreover, this thesis has made a contribution to developmental theory and practice through deconstructing the notion of livestock as a productive asset and introducing the idea of ‘asset-ness’ – the differential qualities and attributes of an asset – that is crucial in understanding the potential benefits and risks involved in incorporating livestock in mixed farming systems. This thesis critically examined the underpinning assumptions of the livestock-based development programmes and highlighted the alternative solutions that are more applicable and inclusive to a broader range of smallholder producers in the rural and peri-urban settings. In doing so, this study called for a more inclusive developmental policy and a programmatic approach to acknowledge alternative pathways of intensification of livestock production that may be more relevant for marginalised farmers. It is further argued that the differences between them would help policymakers and researchers to devise better aimed and context-relevant interventions for smallholder farmers.

Moreover, the research findings from the analysis of differential livestock functions and attributes have broader relevance and implications outside of Rwanda. First, the more comprehensive understanding of asset-ness helps with assessing the recipient's abilities to engage in commercial agriculture more realistically. Second, international NGOs such as Heifer International and other governments who incorporate (livestock or other) asset-based poverty alleviation and social protection strategies could improve their services and support by a differentiated approach that suits better to local production and market conditions, and that matches better with the aspirations of the poor.

Future areas of research

In this thesis, the differences in agricultural and market comparative advantages that exist between the peri-urban and rural areas were of interest and therefore, the study sites were purposively chosen according to the spatial variations and geographical characteristics. Other agricultural regions in the country are of interest for future research. Nyamasheke district in the Western province, for instance, counts as one of the most food insecure and isolated regions in Rwanda. The development and market conditions in such a remote area would present a different set of production challenges than what the current study sites offer. Also, Nyanza in the Southern province could provide an insightful comparative analysis of the case of Rwamagana. Nyanza district has a long tradition of active dairy sector development and

therefore could potentially represent a comparable case study. The findings from this research could benefit further by relating to other agroecological regions and markets, which would deepen our knowledge of regional factors and its macro-level policy implications.

The household survey data could be further enriched by multiple rounds of data collection. Due to constraints in budget and fieldwork schedule, the current study was limited to a single round of survey. Periodical revisits and multiple series of data gathering could reveal other seasonal variations in production management and livelihood strategies that the cross-sectional study might have missed to detect. The factors of seasonality may present different outlook and implications for food consumption and marketing and crop-livestock management.

Finally, the agriculture development experience in Rwanda offers a highly relevant policy case example for many developing countries whose economies and people are primarily dependent on agriculture. Moreover, this thesis contributes to the rural transformation literature that is rapidly gathering policy interest and inciting academic debate. The findings of this research provide more nuanced analyses to the current agriculture development debate in Africa that urges smallholder farmers to embrace commercial agriculture at any cost. However, as the conclusions of this study indicate, the processes of crop-livestock integration are highly variable and differentiated by local production and market conditions and livelihood aspirations and strategies of the farmers. If sustainable intensification research and development policy are to provide a clear answer to smallholder farmers in sub-Saharan Africa, it is necessary to engage with the diverse pathways of intensification. Furthermore, it is essential for the government to deal with the underlying socio-political tensions that persist around the land and past agricultural reforms and policies that undermine the longer-term success of the agricultural and rural development.

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Appendix 1. An overview of the frameworks, models, and terms introduced

Evolutionary paradigm

Malthus's
principle of
population

Boserup's
induced innovation
of agricultural
intensification

Agricultural intensification and crop-livestock integration

von Bertalanffy's
general system &
farm systems

McIntire et al.'s
evolutionary model of
crop and livestock
interaction

Scoones and Wolmer's
multiple pathways of
crop-livestock integration

Development debate, approach and agenda:

Sustainable
agricultural
intensification

Intensification
through (mixed)
integrated crop-
livestock farming

Asset-based
livelihood
development:
livestock as an asset
for smallholders

?

Source: Author's

Appendix 2. List of archives materials

French				
Year	Author/ Department	Original title	Type	Pages
1964	MINIPLAN	Bulletin de statistique	Statistics	19
1969	MINAGRI	Association de l'agriculture et de l'élevage dans les paysannats	Farm report	5
1970a	MINAGRI	Mise en valeur et progrès réalisé dans l'Icyanya	Farm report	7
1970b	MINAGRI	Fiche technique - Bovins (élevage semi-intensif et intensif)	Farm report	2
1971a	MINAGRI	L'association de l'agriculture et de l'élevage	Farm report	5
1971b	MINAGRI	Contribution à l'étude des changements sociaux	Farm report	4
1974	MINIPLAN	Situation Économique de la République Rwandaise au 31 Décembre 1973	Statistics	10
1977a	MINIPLAN	Ile Plan Quinquennal de Développement Économique, Social et Culturel 1977-1981: Volume I - Les Grands Orientations, Les Objectifs Sectoriels et Les Résultats Escomptés	Policies	27
1977b	MINIPLAN	Ile Plan Quinquennal de Développement Économique, Social et Culturel 1977-1981: Volume II - Programmation des Investissements	Policies	20
1978	MINIPLAN & MINAGRI	La disponibilité et l'utilisation de la force de travail au sein de l'exploitation agricole traditionnelle	Research	24
1980	Sauvé, Jean	Groupe Scolaire de Butare - Section Agricole et Vétérinaire : Rapport D'Activité 1979-1980	Annual report	12
1982a	MINAGRI	Bilan de 20 ans d'activités 1962-82	Policies & statistics	29
1982b	National Census Bureau	Recensement Général de la Population et de l'Habitat, 1978: Synthèse des Principaux Résultats	Statistics	13
1982c	MINIPLAN	Loi portant adoption du IIIème Plan Quinquennal de Développement Économique, Social et Culturel 1982-1986	Policies	48
1983	MINITRAV	Premier séminaire national sur l'aménagement du territoire	Policies & research	34
1983a	Présidence de la République	Organisation de l'administration centrale Rwandaise de 1960 à nos jours	Organisational charts & timeline	
1983b	MINAGRI	L'élevage et la production fourragère	Research	5
1983c	MINAGRI	Les petits ruminants en tant que partie intégrante du développement agricole du Rwanda	Research	5

1983d	MINAGRI	L'intégration de l'élevage des petits animaux dans le développement agricole au Rwanda	Research	2
1983e	MINAGRI	Production fourragère et réduction des superficies des exploitations agricoles : La leçon de l'Afrique de l'Est	Research	3
1983f	MINAGRI	Rapport du Séminaire sur la Recherche Agricole au Rwanda : Bilan et Perspectives (Février 5-12 1983) : Recommandations sur les systèmes de production animale	Research	3
1984a	MINAGRI	Discours prononcés par Général-Major Habyarimana Juvénal, Président de la République Rwandaise, À l'occasion du 10ème anniversaire de l'OVAPAM	Official speech	3
1984b	MINAGRI	Discours prononcé par Monsieur Ntezilyayo Anastase, ministre rwandais de l'agriculture, de l'élevage et des forêts, Colloque sur la commercialisation des produits vivriers, à Kigali, 8-11 Mai 1984	Official speech	2
1984c	MINAGRI	Discours prononcé par Monsieur Ntezilyayo Anastase, ministre rwandais de l'agriculture, de l'élevage et des forêts, à la 13ème conférence régionale de la FAO pour l'Afrique, à Harare, Juillet 1984	Official speech	2
1984d	MINAGRI	Discours prononcé par Monsieur Ntezilyayo Anastase, ministre rwandais de l'agriculture, de l'élevage et des forêts, À l'occasion des cérémonies de pose de la première pierre pour le projet de développement rural de Ramba-Gaseke	Official speech	4
1984e	MINAGRI	Discours prononcé par Monsieur Ntezilyayo Anastase, ministre rwandais de l'agriculture, de l'élevage et des forêts, À l'occasion du lancement du projet de reboisement communal Cyeru-Nyamugali-Butaro et du projet de recherche sur l'amélioration des systèmes d'exploitation agricole (<i>Farming Systems Research</i>) dans les communes Cyeru-Nyamugali-Butaro et Nyarutovu	Official speech	2
1985a	ONAPO	La fin de la décennie internationale de la femme et son impact sur le développement au Rwanda	Magazine	3
1985b	ONAPO	Les obstacles liés au programme de population et de production au Rwanda	Magazine	2
1985c	MINAGRI	Méthodologie et résultats sommaires de l'enquête nationale agricole (Phase pilote : mars 1982 – juillet 1983)	Technical report	3
1985d	MINIFINECO	Programme d'Assainissement de Relance de l'Économie Rwandaise	Policies	27
1986a	MINAGRI	Note sur les orientations du sous-secteur vivrier au Rwanda	Technical report	11
1986b	ONAPO	Quelques caractéristiques de l'agriculture au Rwanda et tentatives de spécialisation régionale de quelques cultures	Magazine	2

1986c	MINIPLAN	Résumé du IIIième Plan de développement économique, social et culturel 1982-1986	Policies	8
1986d	MINIFINECO	Situation Économique du Rwanda en 1985	Statistics	13
1986e	MINAGRI	Pertes de terres dues à l'érosion : Résultats de l'enquête pilote sur l'érosion (Année agricole 1984)	Technical report	15
1987	Nshimiyimana, David	Impact de l'OPROVIA sur la régulation du marché rwandais des produits vivriers	Academic thesis	16
1987a	MINAGRI	Attitudes, expériences, conditions et stratégies des exploitants: Distributions de fréquence résultant d'une enquête ponctuelle auprès des ménages ruraux	Research	1
1987b	ONAPO	Éditorial - le thème de l'autosuffisance alimentaire	Magazine	2
1987c	ONAPO	Le concept d'autosuffisance alimentaire et l'équilibre démographique au Rwanda	Magazine	1
1988	MINAGRI	Estimation de la production par les agriculteurs – Résultats d'une enquête menée au Rwanda	Statistics	1
1989	ONAPO	Les menaces de la surpopulation sur l'environnement et les conditions de la vie des rwandais	Magazine	1
1990	MINAGRI	Le rôle de la femme dans l'agriculture rwandaise	Technical report	11
1990a	La Présidence du MRND & ONAPO	Le problème démographique au Rwanda et le cadre de sa solution	Technical report	11
1990b	Gouvernement Rwandais & La Banque Mondiale	Document cadre de politique économique et financière à moyen terme (Octobre 1990 – Septembre 1993)	Policies & technical report	8
1991	Présidence de la République Rwandaise	Rapport de la commission nationale de synthèse sur les réformes politiques au Rwanda	National political charter	14
1992	MINIPLAN	Évolution de la situation économique du Rwanda 1988-91 et tendances 1992	Statistics	18
1997	MINAGRI	Rapport d'activités du Ministère de l'Agriculture, de l'Élevage, de l'Environnement et du Développement Rural (de Juillet 1994 au 31 Décembre 1996)	Statistics	1
1998a	MINAGRI	Rapport d'activités du Ministère de l'Agriculture, de l'Élevage, de l'Environnement et du Développement Rural (Exercice 1997)	Statistics	3
1998b	Le Bureau du Président	Les grandes lignes de la stratégie du Rwanda pour le développement national de l'an 2020	Policies	12
1999	MINAGRI	Rapport d'activités du Ministère de l'Agriculture, de l'Élevage, de l'Environnement et du Développement Rural (Exercice 1998)	Statistics	4

English				
Year	Author/ Department	Original title	Type	Pages
1998	World Bank	Rwanda poverty note	Technical report	102
2002	MINECOFIN	Poverty reduction strategy paper (PRSP)	Policies	160
2004	MINAGRI	National agriculture policy - draft	Policies	44
2004	MINAGRI	Strategic plan for agricultural transformation in Rwanda (PSTA) I	Policies	79
2006	RARDA (now RAB)	The Girinka programme proposal & concept note	Policies	26
2007	MINECOFIN	Economic development & poverty reduction strategy (EDPRS)	Policies	166
2007	NISR	Integrated household living conditions survey (EICV) II	Statistics	104
2007	World Bank	Rwanda note: promoting pro-poor agricultural growth in Rwanda	Technical report	134
2009	MINAGRI	Strategic plan for agricultural transformation in Rwanda (PSTA) II	Policies	123
2009	MINALOC	Ubudehe Concept Note	Policies	13
2008	NISR/MINAGRI	National agriculture survey	Statistics	265
2011	NISR	Integrated household living conditions survey (EICV) III	Statistics	208
2013	RAB	National dairy policy	Policies	48
2013	MINIJUST	Official Gazette: Law No 43/2013 of 16/06/2013 Governing Land in Rwanda	Report	55
2013	MINAGRI	Strategic plan for agricultural transformation in Rwanda (PSTA) III	Policies	18

Appendix 3. Excerpts of the original text in French

Page 75 – « [...] le progrès, c'est travailler pour que le pays avance ».

Page 80 – « De la sorte, étant donné ces prix surfaits pour des produits de subsistance, la rentabilité de productions visant au développement réel du pays (café, thé, viande) apparaît inexistante au paysan, qui préfère demeurer confiné dans une économie de subsistance de bas niveau, où le peu d'efforts qu'il consent est relativement bien rémunéré. La hausse permanente des prix vivriers a donc pour conséquence d'encourager le paysan à travailler peu, produire peu, et maintenir son pays dans une économie pauvre, de subsistance. »

Page 81 – « Ce développement très spectaculaire a bouleversé les conditions du marché : de produit de luxe réservé à une clientèle limitée et acceptant de payer des prix élevés, la pomme de terre est devenue en trois ans un aliment de base de populations rurales et son prix s'est effondré sur tous les marchés, devenant inférieur à celui de la patate douce. »

« [...] les faibles rendements du pyrèthre enregistrés ces dernières années s'expliquent par l'intérêt de plus en plus grand que les paysans manifestent à l'égard de la pomme de terre [...] notamment la pomme de terre qui concurrence sérieusement avec le pyrèthre à Ruhengeri. »

Page 82 – « La conséquence pratique de l'adoption d'un mode d'agriculture intensive en paysannat est que, chaque paysan devra pouvoir disposer d'au moins une, et de préférence deux à trois têtes de gros bétail, de façon justement à produire ce fameux fumier, si nécessaire à l'agriculture. »

Page 83 – « Les pâturages reculent sans cesse devant la houe; seuls les plus mauvais d'entre eux subsistent. Des surfaces que, seul le bétail pouvait valoriser sans en abîmer le potentiel de fertilité, sont ainsi livrées chaque année à la mise en culture. »

Page 84 – « L'application de ces méthodes modernes d'agriculture demandera évidemment un effort accru au paysan dans l'exploitation de son lopin de terre. Il devra d'abord, réduire la durée des jachères en utilisant par exemple des jachères de plantes fourragères et d'engrais vert, appliquer une rotation adéquate dans ses cultures, mais surtout il faudra qu'il apporte des matières de restitution au sol. »

Page 84 – « Le maintien de la fertilité d'une terre de culture peut être normalement assurée par l'enfouissement d'engrais vert, l'application de compost voire même, si la culture est suffisamment « payante » l'utilisation d'engrais minéraux. Mais la seule façon de récupérer des sols dégradés et épuisés, qui ont perdu toute fertilité par suite de cultures trop répétées, est l'application de fortes doses de fumier de ferme. »

Page 86 – « Le mouvement ainsi déclenché par l'adhésion de l'ensemble du Peuple au but propose est ainsi appelé "révolutionnaire" parce que, précisément l'impulsion vient du dedans du Peuple et non injectée de l'extérieur. C'est que la prise de conscience des problèmes nationaux doit être étendue dans le sens d'un phénomène intérieur et non comme d'une imposition d'en haut. Nous devons nous convaincre chaque jour davantage qu'à tous moments, il nous faut « compter d'abord sur nos propres efforts ».

Page 88 – « L'intensification de l'agriculture vivrière s'impose, c'est une condition de survie. »

« L'accroissement des productions vivrières ne s'est fait que grâce à la colonisation et à la récupération des nouvelles terres. Maintenant, cette possibilité est plutôt utopique, les quelques terres restent à récupérer (quelques marais) ne pouvant pas résoudre significativement nos problèmes. Aux lendemains de ces 20 années d'agriculture extensive, le mot d'ordre doit être l'intensification agricole par l'utilisation de plus d'intrants agricoles. »

Page 89 – « L'agriculture rwandaise vise l'autosatisfaction des besoins primordiaux de chaque exploitant agricole familial. Chaque exploitant cherche à produire sur son terrain non seulement le maximum de ce dont il a besoin pour subvenir à la demande de sa famille, mais il essaye également de diversifier les productions en affectant à ses parcelles autant de cultures qu'il y a de goûts à satisfaire (polyculture). On trouvera dans les champs toute une gamme de cultures entremêlées comme si l'agriculteur ne se soucie guère de celles qui lui rapporteraient un maximum de bénéfice net par unité de facteurs de production engagés. »

« L'optimisation régionale des productions sera recherchée en spécialisant les cultures en fonction des caractéristiques agro-climatiques des régions. L'impératif d'accroissement de la productivité ne devra pas s'effectuer aux dépens de la sécurité qui rend nécessaire le maintien d'une certaine diversification. De ce fait, la monoculture ne sera pas prônée. »

Page 90 – « [...] mais aussi de libérer les terres de culture permettant ainsi une exploitation plus aisée et plus productive. »

Page 91 – « Cette deuxième mission du Plan est d'autant plus importante que l'homme constitue la principale richesse du Pays par le potentiel de travail et de création qu'il représente. Le fait qu'il soit encore mal utilisé à des tâches pour lesquelles il n'a pas reçu de formation, ou à des travaux peu productifs, ou plus grave encore, qu'il ne soit pas du tout utilisé, montre le chemin qui reste à couvrir dans la voie du développement. »

Page 91 – « l'intensification des techniques agricoles et des aménagements fonciers. »

Page 93 – « Pour les productions animales, chacun sait que le développement du gros élevage se heurte à des contraintes très fortes inhérentes au milieu naturel, à savoir la réduction inéluctable des terres de pâturage sous la pression démographique. Il s'agira donc pour lui d'intensification plus que d'accroissement en valeur absolue. »

Page 95 – « On ne connaît aucun petit paysan qui ait dû renoncer une activité rémunératrice pour prendre soin de petits animaux. Au contraire, les revenus des petits fermiers se trouvent accrus par l'élevage de petits animaux puisqu'il est fait appel à une main d'œuvre sous employée. »

Page 96 – « La production alimentaire, agricole et animale est, vous le savez déjà, la priorité première de notre plan de développement. [...] Nous n'aurons jamais assez insisté sur la nécessité d'allier l'agriculture et l'élevage. »

« Le projet 'Farming Systems' est constitué à la base par une analyse profonde du secteur rural : étude du milieu physique (sols, climats, ressources en eau, etc.) mais surtout la connaissance de l'acteur du développement, le producteur : son environnement socioéconomique, ses contraintes, ses modalités de prise de décision et ses propres motivations. [...] »

Vive les militantes et les militants réunis au sein du M.R.N.D.!

Vive le mariage de l'Agriculture moderne à l'Élevage amélioré! »

Page 97 – « Les épandages du fumier et de compost sont certes les meilleurs moyens de réaliser des apports de matières organiques dans les sols; mais souvent, l'un et l'autre font défaut ou sont disponibles en quantités insuffisantes. »

Page 98 – « Étant donné d'une part le contexte du secteur rural rwandais tel que décrit précédemment et d'autre part l'horizon de planification pour le III^{ème} Plan Quinquennal, il semble judicieux de s'engager résolument en priorité dans la stratégie de l'amélioration des techniques culturales et d'élevage traditionnelles pour l'horizon 1986, tout en consacrant à la technologie moderne des moyens dimensionnés sur une phase expérimentale, elle-même devant évoluer avec le milieu d'accueil du transfert de technologie. »

« Les essais de l'ISAR concernant l'étable fumière et la compostière ainsi que leur adoption par un certain nombre d'agriculteurs pour la fabrication de matière organique fertilisante constituent à l'heure actuelle, la technologie la plus appropriée en vue de la conservation et de l'amélioration de la fertilité des sols. »

Appendix 4. Household survey questionnaire

Agricultural Intensification and Smallholder Crop-livestock Integration in Rwanda	
IDENTIFICATION INFORMATION	
GEOGRAPHIC IDENTIFICATION	INTERVIEW RECORD
SECTOR: _____ CELL: _____ VILLAGE: _____ HOUSEHOLD ID: _____	ENUMERATOR/TRANSLATOR Name : _____ Signature : _____ Date : _____ Remarks: _____ _____ _____ _____ _____
SELECTING THE RESPONDENT(S) First, read the consent form to the respondent(s), explain and answer any question that the respondent(s) may have before starting the interview. Once the respondent(s) have clearly understood and agree to participate, have her/him sign the consent form and begin the interview. Administer this questionnaire to the <u>primary person in charge of crop and/or livestock production</u> . For the food security questions, ask the <u>primary person in charge of household food purchasing and cooking</u> .	FIELD COORDINATOR Name : <u>Sung Kyu Kim</u> Signature : _____ Date : _____ Remarks: _____ _____ _____ _____ _____

SECTION 1: HOUSEHOLD SIZE & COMPOSITION				
Person	A. Description*	B. Age	C. Gender	D. Work
HH1				
HH 2				
HH 3				
HH 4				
HH 5				
HH 6				
HH 7				
HH 8				
HH 9				
HH 10				
HH 11				
HH 12				
HH 13				
HH 14				

<p>A. Household (HH) membership* * People living in the same compound and sharing the same meal</p> <p><u>In relationship to the head of household</u></p> <ol style="list-style-type: none"> Head of household Wife or Husband Daughter or Son Grandchild Step or adopted child Sister or Brother Mother or Father Grand-mother or Grand-father Domestic worker Farm/livestock care worker <p>C. Gender 1=Female 2=Male</p>	<p>D. Work</p> <p>On-Farm work</p> <ol style="list-style-type: none"> Crop farming Livestock rearing Crop and livestock farming Fishing <p>Non-Farm (Formal & Wage)</p> <ol style="list-style-type: none"> Manufacturing (industry) Service (e.g. hotel & restaurant, transport, etc.) Technical & Professional (e.g. mason, teacher, etc.) Own business <p>Informal (Self-employed)</p> <ol style="list-style-type: none"> Trade; Labour (farm- or non-farm work) <p>Dependent</p> <ol style="list-style-type: none"> Not working, Inactive
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SECTION 2: HOUSEHOLD ASSETS AND ACCESS TO RESOURCES		
1. BY OBSERVATION – What type of habitat is the household located in?	1. Unplanned clustered rural housing 2. Agglomeration (Umuḍugudu) 3. Isolated rural housing 4. Modern planned area	<input type="checkbox"/>
2. What is the occupancy status of the household?	1. Owner occupier (no loan or mortgage) 2. Owned with loan or mortgage 3. Tenancy (renting) 4. Dwelling provided by employer 5. Dwelling provided free of charge 6. Other type of occupancy status: _____	<input type="checkbox"/>
3. What is the main material of the floor of the house?	1. Mud, sand, earth 2. Wood floor 3. Vinyl, tile, cement, carpet	<input type="checkbox"/>
4. What is the main material of the wall of the house?	1. Mud bricks 2. Mud bricks covered with cement 3. Tree trunks with mud 4. Tree trunks with mud and cement 5. Oven fired bricks 6. Other: _____	<input type="checkbox"/>
5. Does the household have electricity from a power line in the house?	0 = No 1 = Yes	<input type="checkbox"/>
6. What type of fuel does your household usually use for cooking?	1. Firewood 2. Charcoal 3. Straw, grass, crop waste 4. LPG (Liquid Propane Gas) / Gaz 5. Electricity 6. Biogas 7. Animal dung 8. Other – Specify: _____	<input type="checkbox"/>
7. What type of fuel does your household usually use for lighting?	1. Electricity 2. Candle 3. Firewood 4. Oil lamp 5. Battery torch 6. Solar lamp 7. Other – Specify: _____	<input type="checkbox"/>
8. Does the household have access to and use internet from home (modem, mobile phone)?	0 = No 1 = Yes	<input type="checkbox"/>
9. Does your household have: Code: 0=No 1=Yes (Select all applicable items)	1. A working radio 2. A working television 3. A telephone (mobile) 4. A computer 5. A refrigerator 6. A living room suite 7. A bed (frame with foam mattress) 8. A traditional bed mattress 9. A sewing machine 10. Bicycle 11. Motorcycle/scooter 12. Car or truck	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/> 8 <input type="checkbox"/> 9 <input type="checkbox"/> 10 <input type="checkbox"/> 11 <input type="checkbox"/> 12 <input type="checkbox"/>

1. What type of sanitation facility does the household have?	1. Traditional pit latrine (without floor slab) 2. Traditional pit latrine (with floor slab) 3. Ventilated improved pit latrine 4. Flush toilet 5. No facility, bush, field 6. Other – Specify _____	<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div>
2. What is the main mode of traveling to the nearest water source?	1. Walk 2. Bicycle 3. Moto 4. Car 5. Other – specify: _____	<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div>
3. How long does it take to go to the source of drinking water (one-way)?		<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div> <div style="text-align: center;">minutes</div>
4. What is the main mode of traveling to the nearest market?	1. Walk 2. Bicycle 3. Moto 4. Car 5. Other – specify: _____	<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div>
5. How long does it take you to travel to the nearest market (one-way)?		<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div> <div style="text-align: center;">minutes</div>
6. How long does it take you to reach the nearest main road by walk (tarmac, paved road)?		<div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div> <div style="text-align: center;">minutes</div>

Section 3: LAND**Subsection 3.1: LAND USE*****Plot areas and crop/fodder***

	A	B	C	D
Plot	Area (ha)	Dist to HH (min)	Type of access	Type of use
1				
2				
3				
4				
5				
6				
Kit.G.				
		E	F	G
Plot	Season	Crop/ Fodder	Home consumpt.	Sold to market
1	B			
	C			
	A			
2	B			
	C			
	A			
3	B			
	C			
	A			
4	B			
	C			
	A			
5	B			
	C			
	A			
6	B			
	C			
	A			
Kit.G.	B,C,A			

C. Type of access

1. Own
2. Rented
3. Communal
4. Free access

D. Type of use

1. Crop
2. Fodder
3. Both
4. Fallow
5. Not used

Crop and fodder list	
<i>Roots/tubers (Ibinyabijumba)</i>	
1=Potatoes (Ibirayi)	3=Cassava (Imyumbati)
2=Sweet potatoes (Ibijumba)	4=Colocasia (taro) (Amateke)
<i>Cereal (Ibinyampeke)</i>	
5=Maize (Ibigori)	7=Wheat (Ingano)
6=Sorghum (Amasaka)	8=Rice (Umuceri)
<i>Legume (Ibinyamisogwe)</i>	
9=Beans (Ibishyimbo)	11=French beans (Imiteja)
10=Soybeans (Soya)	12=Green peas (Amashaza)
13=Banana (Urutoki)	
<i>Nuts (Ubunyobwa)</i>	
14=Peanuts, Sunflower seeds (Ubunyobwa, Ibihwagari)	
<i>Vegetable (Imboga)</i>	
15=Cassava green (Isombe), local green (dodo),	17=Tomatoes (Inyanya)
16=Eggplant (Intoryi), Squash (amadegede)	18=Onion(igitunguru)
<i>Fruits (Imbutu)</i>	
19=Passion fruit (Amatunda), Lemon (Indimu), Prune (Ibinyomoro)	21=Avocado (Avoka)
20=Papaya (IPapayi), Mango (Imyembe)	22= Pineapple (Inanasi)
<i>Cash crops (Ibihingwa ngenga bukungu)</i>	
23=Sugar cane (Ibisheke), Coffee (Ikawa), Tea (Icyayi)	
<i>Forage shrub and trees (Ibiti)</i>	
24=Calliandra, Leucaena, Avocado tree leaves	
<i>Forage grasses (Ubwatsi bwamatungo) and leguminous</i>	
25=Tripsacum, Setaria, Pennisetum,	Napier grass (Urubingo), Kikuyu grass, Couch grass (Urwiri)
26=Mukuna sp. (Mukuna beans)	

SECTION 4: LIVESTOCK INFORMATION

1. FOR RUMINANTS – Livestock ownership, species and purpose, herd structure and calving pattern

Species	(A) CATTLE									
Breed	(i) LOCAL (ii) CROSS (iii) PURE/EXOTIC									
	Female							Male		
	Number	Breed	Lact. (mth)	Preg. (mth)	No. of sold last year	No. of death last year		Number	No. of sold last year	No. of death last year
Calves			/							
Mature										
TOTAL										

Purpose 0=No 1=Yes	1. Milk 2. Meat 3. Manure 4. Breeding 5. Saving <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	1. Meat 2. Manure 3. Breeding 4. Saving <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
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Species	(B) GOAT		
	Number	No. of sold last year	No. of death last year
TOTAL			
Purpose 0=No 1=Yes	1. Meat 2. Manure 3. Breeding 4. Saving <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		

** OPEN ENDED QUESTION **

3. If the household has no small livestock, ask why they are not rearing small animals.

2. FOR NON-RUMINANTS –

Species	Number	No. of sold last year	No. of death last year	Purpose 0=No 1=Yes
Pig				1. Meat 2. Manure 3. Breeding 4. Saving <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Chicken/ Duck				1. Egg 2. Meat 3. Manure 4. Breeding 5. Saving <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Rabbit				1. Fur 2. Meat 3. Manure 4. Breeding 5. Saving <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

SECTION 5: LIVESTOCK PRODUCTION INPUTS		
<p><u>NOTE – Skip Q1 & 2 if only chicken is reared.</u></p>		
1. Did you have enough grass to feed your animal(s) from last year (including the dry season) up to now?	0 = No 1 = Yes → Go to Q ()	<input type="checkbox"/>
2. If you did not have enough, how did you manage to feed grass to your animal(s)? Code: 0=No 1=Yes (Select all applicable items)	1. Purchase from neighbor & family 2. Purchase from market 3. Trade/In-kind from neighbor & family 4. Collect or graze in public areas (way-side, vacant land) 5. Other – Specify: _____	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/>
3. Other than the grass, what other feed stuff did you give to your <u>animal(s)</u> ? Code: 0=No 1=Yes (Select all applicable items)	1. Maize bran 2. Rice bran 3. Pre-mix commercial feed 4. Banana leaves/stem 5. Maize, sorghum leaves 6. Tree leaves (Calliandra, Leucaena) 7. Wild grasses (weed) 8. Silage (molasses, urea, biomass) 9. Mineral block 10. Leftover household food/crop residues 11. Other – Specify: _____	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/> 8 <input type="checkbox"/> 9 <input type="checkbox"/> 10 <input type="checkbox"/> 11 <input type="checkbox"/>
4. What is the main source of drinking water for your animal(s)?	1. Piped into dwelling/compound/plot 2. Public tap (with fee) 3. Public tap (free) 4. River, stream, pond, lake 5. Rainwater 6. Boreholes 7. Other – Specify: _____	<input type="checkbox"/>
<p>**OPEN ENDED QUESTION**</p>		
5. If you have any question about <u>animal keeping and management such as feeding, reproduction, health and hygiene, buying and selling animal or milk, and organic composting</u> , where or from whom do you get the necessary information?		
6. When you have a <u>problem with your animal such as disease, pregnancy, feed shortages, and milk quality</u> , where or from whom do you get the help and support?		
7. How often do you call the veterinarian to come and check your animal(s)?	1. Never → Go to Q8 2. Only when animal(s) have problem and/or for artificial insemination 3. Regularly (monthly) 4. Frequently (weekly) 5. Other – Specify: _____	<input type="checkbox"/>
8. How do you plan and manage reproduction/pregnancy?	1. Naturally (renting a male) 2. Artificial insemination	<input type="checkbox"/>

SECTION 6: LIVESTOCK PRODUCTION OUTPUTS – CATTLE		
SECTION 6.1 – MILK PRODUCTION, CONSUMPTION AND SALES		
NOTE: FOR Q1 to Q4 –For currently lactating cow(s). If the cow(s) are currently dry, ask in reference to <u>last lactation period</u> .		
1. On average, how much milk do you get in total per day?	Per day	Litre
2. How much milk do you usually keep for home consumption, for sales and/or for sharing with families and neighbors?	A. Home	Litre
	B. Sales	Litre
	C. Giving	Litre
NOTE: Ask only if Q2-B was answered –	1. Neighbors (from home) 2. Intermediary (bicycle boys) 3. Restaurant/Alimentation 4. Milk collection center 5. Other – Specify: _____	
3. Where or to whom do you sell the milk to?		
4. How long does it take you to deliver and reach the closest milk sale point (one-way)?		minutes
** OPEN ENDED QUESTION** 5. Selling and buying of animals – - When (or in what occasion) do you usually sell your animal? - When (or in what occasion) do you usually buy new animal? - Where and how do you sell and buy animal (at the market; through individual buyer/seller or intermediary)? 6. Given the current conditions of farming and family situation, are there ways in which you can <u>increase (milk or egg) production and/or improve reproduction rate</u> (that is, increasing production and revenue)?		
SECTION 6.2 – SOIL FERTILITY AND NUTRIENT MANAGEMENT		
7. How fertile are your plots?	1. Fertile (need little manure) 2. Medium (should use manure) 3. Poor (must use manure)	
8. Did you use any chemical fertilizer for crop production last year?	0 = No → Go to Q9 1 = Yes	
9. Which fertiliser did you use and how much quantity did you apply?	1. DAP 2. UREA 3. NPK	1 Kg 2 Kg 3 Kg
10. Did you have enough manure to apply for all your farming needs last year?	0 = No 1 = Yes → Go to Q12	

1. If you did not have enough, how did you manage the soil on your plots? Code: 0=No 1=Yes (Select all applicable items)	1. Trade/In-kind cow manure 2. Purchase cow manure 3. Household compost 4. Small livestock manure 5. Gift/free access to manure 6. Nothing 7. Other – Specify:	1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/>
<p>** OPEN ENDED QUESTION **</p> <p>2. Can you please tell me in detail how you <u>collect</u>, <u>keep</u> and <u>apply</u> manure?</p> <p>- Manure collection:</p> <p>- Manure composting:</p> <p>- Manure application:</p>		
SECTION 7: HOUSEHOLD FOOD CONSUMPTION		
Have any of the following food been prepared and consumed by the <u>household members</u> :		
FOOD	1. Yesterday? 0=No → Ask Q2 1=Yes	2. In the past week? 0=No 1=Yes
1. Any maize, sorghum	<input type="checkbox"/>	<input type="checkbox"/>
2. Any rice, macaroni, bread	<input type="checkbox"/>	<input type="checkbox"/>
3. Any potatoes, manioc, sweet potatoes, coloquase or other white root vegetables, green (cooking) bananas	<input type="checkbox"/>	<input type="checkbox"/>
4. Any vegetables such as isombe, dodo, onion, tomatoes, carrots, eggplant	<input type="checkbox"/>	<input type="checkbox"/>
5. Any fruits such as mangoes, papayas, indimu, passion fruit, plum	<input type="checkbox"/>	<input type="checkbox"/>
6. Any meat	<input type="checkbox"/>	<input type="checkbox"/>
7. Any eggs	<input type="checkbox"/>	<input type="checkbox"/>
8. Any canned or dried fish	<input type="checkbox"/>	<input type="checkbox"/>
9. Any foods made from beans, lentils, peas, soja, peanuts or sunflower seeds	<input type="checkbox"/>	<input type="checkbox"/>
10. Any food made with oil, butter, margarine or fats	<input type="checkbox"/>	<input type="checkbox"/>
11. Any sugar or sugary foods such as cakes, pastries, biscuits, sugar cane	<input type="checkbox"/>	<input type="checkbox"/>
12. Any milk	<input type="checkbox"/>	<input type="checkbox"/>
3. Was this a typical day's and/or week's food intake for the household?	0 = No → Go to Q4 1 = Yes	<input type="checkbox"/>
<p>**OPEN ENDED QUESTION**</p> <p>4. If it was not a typical household diet, why was it not?</p>		

SECTION 8: OWNERSHIP AND ACCESS TO LIVESTOCK

You are currently not rearing any animal.

1. Have you ever owned or kept (for another person) animal such as goat, chicken, pig and/or cow?

A) If yes, what is the main reason for not rearing one now?

B) If you have never reared an animal, what is the main reason for not having the chance to rear one?

2. There are many benefits from keeping a livestock but there are also many costs involved in caring, feeding and managing a livestock.

Given your current land, working condition and family situation (number of dependent like children and elderly parents), which animal, if any, would be most practical and realistic for your household to keep and rear?

3. Can you please tell us the benefits and costs involved in rearing the animal you chose above?

Benefits

Costs

Wellbeing

Risks

1. Are there ways in which you can start rearing an animal without buying or spending your own money?

A) If yes, can you please describe how this arrangement would work?

B) If you are aware of such an arrangement but cannot undertake one, please explain why you cannot.

2. *If you are not able to or not willing to partake in a social, livestock sharing arrangement like Ubudehe, kwitura, or livestock-in-kind –*

One possible way to start livestock rearing is to buy small animals (that is not too expensive) and to breed them for sale and saving. Then as your savings and means to take care of animals increase, you can buy bigger animal. (This gradual upgrading of species is called “livestock ladder”)

A) For example, given your current land, working condition and family situation, do you think it is possible for you to start rearing small animals (such as few chicken or rabbit) and eventually grow the savings and capacity to buy larger animals (such as goat and pig, and cow)?

B) If you believe that you can gradually improve the livestock production from small animals to larger animals, how long do you think it will take you to do achieve the upgrading?

- From (chicken) to (goat):

- From () to ():

- From (goat) to (cow):

3. What are some challenges that make this “livestock ladder” plan difficult to put into action today?

Appendix 5. Research and ethics clearance and approval

REPUBLIC OF RWANDA



MINISTRY OF EDUCATION
P.O.BOX 622 KIGALI



Kigali, 04/02/2015

N° 026/12.00/2015



Re: Permission to Carry out Research in Rwanda - No: MINEDUC/S&T/287/2015

The Permission is hereby granted to **Mr. Sung Kyu Kim**, Ph.D Student, Institute of Development Studies at the University of Sussex, UK, to carry out research on: **"Agricultural Intensification and Smallholder Crop-Livestock Integration in Rwanda"**.

The research will be carried out in three selected villages from Nyamasheke, Nyanza and Rwamagana Districts.

The researcher will need access to Agricultural Developments, Reports, Technical Paper and Policy Briefs from National Archives. He will need to interview officials from the Ministry of Agriculture and Animals Resources, Rwanda Agriculture Board-RAB, Local Government Extension Agents (Veterinary and Agriculture Workers). He will need also to interview Local farmers, Agro-product and Service Providers, and dairy cooperative members who will be selected in collaboration with the local authorities.

The period of research is from **02nd February, 2015 to 01th February, 2016**. It may be renewed if necessary, in which case a new permission will be sought by the researcher.

Please allow the **above mentioned researcher**, any help and support he might require to conduct this research

Yours sincerely

MINISTRE DE L'EDUCATION
GASINGIRWA Marie-Christine, Ph.D
Directrice Générale de la Recherche
et de l'Innovation

Marie-Christine GASINGIRWA (Ph.D)
Director General,
Science Technology and Research
Ministry of Education



REPUBLIC OF RWANDA

Kigali, 04/09/2015
N° 0268/12.00/2015MINISTRY OF EDUCATION
P.O.BOX 622 KIGALI

Mr. Sung Kyu Kim,
Ph.D Student,
Institute of Development Studies
University of Sussex
UK
Email: s.kim@ids.ac.uk
sun9kyu.kim@gmail.com

RE: Approval to Conduct Research in Rwanda under the Project Title: "Agricultural Intensification and Smallholder Crop-Livestock Integration in Rwanda"

I am pleased to attach a copy of research clearance, which has been granted to you to conduct research on the above title.

I wish to remind you that the research clearance number should be cited in your final research report. The research should be carried out under affiliation of the Institute of Policy Analysis and Research-Rwanda (IPAR), under supervision of Dr. Alfred BIZOZA, Director of Research, IPAR.

You are requested to submit the progress report after Six Months and final report after completion of your research activities to the Ministry of Education of Rwanda.

I wish you success in your research.

Yours sincerely,

MINISTRE DE L'EDUCATION
GASINGIRWA Marie-Christine Ph.D
Directrice Générale
Recherche et Technologie



Marie-Christine GASINGIRWA (Ph.D)
Director General,
Science Technology and Research
Ministry of Education

Cc.

- Hon. Minister of Education
- Hon. Minister of State in Charge of Primary and Secondary Education
- Hon. Minister of State in Charge of TVET
- Permanent Secretary, Ministry of Education
- Dr. Alfred BIZOZA, Director of Research, IPAR

REPUBLIC OF RWANDA

Rwamagana, 16th /02/2015

N° 0126/05-01105



**EASTERN PROVINCE
RWAMAGANA DISTRICT**
Email rwamaganadistrict@gmail.com.
B P 24 Rwamagana

Sung Kyu Kim
PhD student
Institute of Development Studies (IDS)
University of Sussex

RE : Response of your letter

Dear Sir,

Reference is made to your letter dated 09th February 2015 in which you requested permission to conduct research fieldwork (observation, interviews, surveys and field visits) at Rwamagana District and you will get data by interview with the district and sector officers (Agronomists, Veterinarians,.....) and with various famers and their household members,

I hereby inform you that you are allowed to conduct your research in Rwamagana District.

Yours Sincerely

Yvonne MUHONGAYIRE
Acting Mayor of Rwamagana District

Cc :

- Executive Secretary of Rwamagana District
- Agronomist of Rwamagana District
- Veterinary of Rwamagana District
- Executive Secretary of Sector (All)

REPUBLIC OF RWANDA



SOUTHERN PROVINCE

NYANZA DISTRICT

Date: March, 9th 2015

N°: 6.11/02/02/01/2015

Mr Sung Kyu Kim

Institute of Development Studies (IDS) University of Sussex

Dear Sir,

Re: Accepting request for conducting Research in Nyanza District

Reference made to your letter requesting for approval to conduct your Research titled «Agricultural intensification and smallholder crop-livestock integration in Rwanda»; it's my pleasure to inform you that your request has been accepted. So you are welcome to start your dissertation in our District.

Sincerely,

MURENZI Abdallah



The Mayor of Nyanza District

Cc:

- Mr Vice Mayor in charge economic development

DUKORANE UMURAVA, DUTERE IMBERE

Appendix 6. Life history interview questions

Guiding questions from Atkinson (1998)

- What was going on in your family, your community, and the world at the time of your birth?
- What is your earliest memory?
- Was your family different from other families in your neighbourhood?
- What do you remember most about growing up with, or without, brothers and sisters?
- What were some of your struggles as a child?
- How old were you when you left your parents' home?
- What social pressures have you experienced as an adult?
- How far did you go with your formal education?
- Are you satisfied with the level of formal education you achieved?
- What has been your most important lesson in life, outside of the classroom?
- Are you married?
- Do you have children?
- Did you have any dreams or ambitions as a child? As an adolescent?
- What were your hopes and dreams as you entered adulthood?
- What events or experiences helped you understand and accept your adult responsibilities?
- Why did you do this work?
- What was the most important historical event you participated in?
- Do you remember what you were doing on any of the really important days in our history (name some examples)?
- What is the most important thing given to you by your family?
- How do you feel about your life now that you are older (and retired)?
- What do you do with your time now?
- Have all your children left home?
- Do you have grandchildren?
- What transitions or turning points did you experience in your life?
- What changes have you undergone since childhood, adolescence and adulthood?
- Do you feel you are in control of your life?
- What gifts (tangible and intangible) are still important to you?
- What were the crucial decisions in your life?
- What has been the most important learning experience in your life?
- Have there been any mistakes in your life?
- How have you overcome or learned from your difficulties?
- Are you satisfied with the life choices you have made?
- Has there been a special [occasion or event] that has changed your life?
- What is your biggest worry now?
- What has been the greatest challenge of your life so far?
- What matters the most to you now?
- Where do you see for yourself in the future, in 5, 15, 25 years?
- Is there anything that we've left out of your life story?
- Do you feel you have given a fair picture of yourself?
- What are your feelings about this interview and all that we have covered?

Appendix 7. On principal components

Excerpt from (Filmer and Pritchett, 2001)

Principal components is a technique for extracting from a set of variables those few orthogonal linear combinations of the variables that capture the common information most successfully. Intuitively the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information that is common to all of the variables.

Suppose we have a set of N variables, a_{1j}^* to a_{Nj}^* , representing the ownership of N assets by each household j . Principal components starts by specifying each variable normalised by its mean and standard deviation. For example,

$$a_{1j} = \frac{(a_{1j}^* - a_1^*)}{s_1^*}$$

where a_1^* is the mean of a_{1j}^* across households and s_1^* is its standard deviation. These selected variables are expressed as linear combination of a set of underlying components for each household j :

$$\begin{aligned} a_{1j} &= (v_{11} \times A_{1j}) + (v_{12} \times A_{2j}) + \dots + (v_{1N} \times A_{Nj}) \\ &\dots \qquad \qquad \qquad (j = 1, \dots, J) \\ a_{Nj} &= (v_{N1} \times A_{1j}) + (v_{N2} \times A_{2j}) + \dots + (v_{NN} \times A_{Nj}), \end{aligned} \tag{1}$$

where the A s are the components and the v s are the coefficients on each component for each variable (and do not vary across households). Because only the left-hand side of each line is observed, the solution is indeterminate.

Principal components overcomes this indeterminacy by finding the linear combination of the variables with maximum variance – the first principal component A_{1j} – and then finding a second linear combination of the variables, orthogonal to the first, with maximal remaining variance, and so on.

Technically the procedure solves the equations $(\mathbf{R} - \lambda_n \mathbf{I})\mathbf{v}_n = 0$ for λ_n and \mathbf{v}_n , where \mathbf{R} is the matrix of correlations between the scaled variables (the a s) and \mathbf{v}_n is the vector of coefficients on the n th component for each variable. Solving the equation yields the characteristic roots of \mathbf{R} , λ_n (also known as eigenvalues) and their associated eigenvectors, \mathbf{v}_n . The final set of estimates is produced by scaling the \mathbf{v}_n s so the sum of their squares sums to the total variance, another restriction imposed to achieve determinacy of the problem.

The “scoring factors” from the model are recovered by inverting the system implied by Equation (1), and yield a set of estimates for each of the N principal components:

$$\begin{aligned} A_{1j} &= (f_{11} \times a_{1j}) + (f_{12} \times a_{2j}) + \dots + (f_{1N} \times a_{Nj}) \\ &\dots \qquad \qquad \qquad (j = 1, \dots, J) \\ A_{Nj} &= (f_{N1} \times a_{1j}) + (f_{N2} \times a_{2j}) + \dots + (f_{NN} \times a_{Nj}). \end{aligned} \tag{2}$$

The first principal component, expressed in terms of the original (unnormalised) variables, is therefore an index for each household based on the expression

$$A_{1j} = f_{11} \times (a_{1j}^* - a_1^*)/s_1^* + \cdots + f_{1N} \times (a_{Nj}^* - a_N^*)/s_N^*. \quad (3)$$

The crucial assumption for our analysis is that household long-run wealth explains the maximum variance (and covariance) in the asset variables. There is no way to test this assumption directly, but in the following sections we provide evidence that this method produces reasonable results.

Appendix 8. List of interviewed farmers/members of Kigabiro-MCC

Pseudonym	Gender	Birth year	Interviewed	Village	Key themes	Turning points*
Mugwaneza	F		13 March 2015	Bigabiro	Dairy business in partnership	Dairy business (+/-)
Mazimpaka	M	1944	12 March 2015	Nsinda	Ugandan diaspora; politics of land concessions	Gaining and losing access to land concessions (+/--)
Mushikiwabo	F		19 March 2015	Rebero	Purchasing grass vs. Growing own grass dilemma	Family loss during the genocide (--); strong extended family support (+)
Mihigo	M		13 March 2015	Munini	Pasture ranching system; traditional dairy transformation	Selling milk for cash (+)
Nshuti	M		13 March 2015	Kigabiro*	One cow; small livestock theft; work as tailor	One cow production in conjunction with tailor work (+)
Niyonyugura	F		12 March 2015	Kigondo	One cow; Heifer International programme	Husband's death (--); Heifer cow programme (+)
Gasimba	M		12 March 2015	Kibare	Veterinary specialist; passing on the family business	Taking a loan to expand dairy production (+); one of the sons pursuing to become a veterinarian (+)
Murangwa	M		19 March 2015	Rebero	Reduce herd size but improve the feeding quality	Milk pricing (--/+)
Bisangwa	F		12 March 2015	Nsinga	Insighful veterinary service experience	Loss of animal by disease, accident and theft (--)
Munyentwali	M	1929	20 March 2015	Rubina	Political struggle in 1960s; Ugandan diaspora	Trouble with access to family land in Gisenyi and starting up in Rwamagana (+)
Twahirwa	M		12 March 2015	Akabeza	Ugandan diaspora; weak family support network	In care of grand-children (--)
Usabuwera	M	1969	13 March 2015	Kigega	Dairy expansion from one cow to pasture ranching system; DRC diaspora	One cow production (-); taking a loan and investment in dairy (+); end of project work and future job prospect (--)
Kwizera	F	1974	20 March 2015	Mpinga	One cow; kidnapped and returned from Tanzania ; prefers to expand dairy over crops	First marriage (--); returning from Tanzania (--); starting up with one cow (+)

Note: interviewed at the Milk Collection Centre at Kigabiro sector

* - constant; -- negative; + positive